User and maintenance manual for generating sets

R44C3

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1. Preface

1.1. General recommendations

Thank you for choosing an electrical generating set from our company.

This manual has been designed to help you operate and maintain your electrical generating set correctly.
The information contained in this manual is taken from technical data available at the time of print. In line with our policy of continually improving the quality of our products, this information may be amended without warning.

Read the safety instructions attentively in order to prevent any accidents, faults or damage. These instructions must always be followed.

You are likely to encounter several warning symbols in this manual.

Danger	This symbol indicates an immediate danger to human health and life in case of exposure. Failure to follow the corresponding advice entails serious consequences for human health and life in case of exposure.

Warning	This symbol draws attention to the potential risks to human health and life in case of exposure. Failure to follow the corresponding advice entails serious consequences for human health and life in case of exposure.

Important	This symbol indicates a dangerous situation if the warning is not heeded. Failure to follow the corresponding advice risks resulting in minor injury of personnel or damage to any other object in case of exposure.

In order to obtain optimum efficiency and the longest possible life for the electrical generating sets, maintenance operations must be carried out according to the periods indicated in the attached preventative maintenance tables. If the electrical generating set is used under dusty or unfavourable conditions, some of these periods will be shorter.

Ensure that all repairs and adjustments are carried out by personnel who have received appropriate training. Dealers have this qualification, and can answer all of your questions. They can also supply you with spare parts and other services.

The left and right sides can be seen from the back of the electrical generating set (the radiator is at the front).

Our electrical generating sets have been designed so that damaged or worn parts can be replaced by new or reconditioned parts thereby reducing the out of action period to a minimum.
For any replacement of parts, contact your nearest dealer for our company who will have the necessary equipment and can offer properly trained and informed staff to carry out maintenance, parts replacement and even total reconditioning of generating sets.

Contact your local dealer for the available repair manuals and to make the necessary arrangements for training personnel in implementation and maintenance.

Important	Some user and maintenance manuals for the engines fitted to generating sets cover control units and include the start-up and shutdown procedures for the engines. As the generating sets are fitted with control units that are specific to the generating sets, only the information that appears in the documentation for the generating sets' control units should be taken into consideration. In addition, according to the manufacturing criteria of the generating sets, some engines may be fitted with specific electrical wiring different to that described in the engine documentation.

1.2. Pictograms and their meanings

Safety notices are clearly mounted on the equipment to draw the operator's or maintenance technician's attention to the potential dangers and explain the action to be taken in the interest of safety. These notices are reproduced in this publication for ease of identification by the operator.
Replace any notice that is missing or illegible.

Warning: danger	Publications delivered with the generating set must be referred to	Warning: risk of explosion
Warning: risk of electric shock	Protective clothing must be worn	Naked flames and unprotected lights prohibited. No smoking
Warning: toxic materials	Your eyes and ears must be protected	Entry prohibited to non-authorised persons
Warning: pressurised fluids	Periodic maintenance must be carried out	Jet washing prohibited
Warning: high temperature, risk of burns	Battery level must be checked	Earth
Warning: rotating or moving parts (risk of getting caught in the machinery)	Lifting point required	Warning: corrosive product

Figure 1.1: Pictograms and their meanings

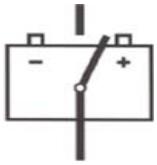
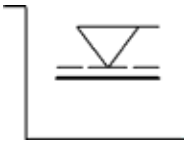
 Battery isolating switch	Fuel	External fuel connections
Inspection hatch	Retention container drainage	Fuel drainage
Oil drainage	Oil filling	Coolant filling
Coolant drainage	Forklift required for lifting	 Bulk tank level high
Fuel supply selection valves	During any operation on the batteries, wear protective glasses and protective clothing	Rinse any splashes of acid on the skin or in the eyes using clean water. Consult a doctor immediately. Contaminated clothes must be washed with water
① ②	① Important: refer to the documentation accompanying the generating set. ② Warning: emission of toxic exhaust gases. Do not use in a confined or badly ventilated area.	

Figure 1.1 (continued) : Pictograms and their meanings

1.3. Instructions and safety regulations

THESE SAFETY GUIDELINES ARE IMPORTANT

If you do not understand or have any questions about any point in this manual, contact your dealer who will explain it to you or give you a demonstration. A list of risks and precautionary measures to take follows. You should also refer to any local and national regulations that apply in accordance with your own jurisdiction.

KEEP THIS MANUAL

This manual contains important instructions which must be followed when installing or carrying out maintenance on a generating set or batteries.

1.3.1 General advice

Use

- ✓ The operating and safety instructions must be made known to operating personnel. They will be regularly updated.
- ✓ Read and understand the manuals provided with the generating set, pump unit or lighting column properly. The manufacturer's instructions must remain at the disposal of technicians, if possible in situ.
- ✓ The facility must be operated under the direct or indirect supervision of a person appointed by the operator, who is familiar with the operation of the facility, and the dangers and drawbacks of the products used or stored in the facility.
- ✓ Do not wear loose clothing, or get close to machines in operation. Note that the fans are not clearly visible when the engine is running.
- ✓ Warn personnel present to keep their distance during operation.
- ✓ Do not run the generating set, pump unit or lighting column without refitting the protective covers and closing all the access doors.
- ✓ Never let a child touch the generating set, pump unit or lighting column, even when shut down.
- ✓ Avoid operating the generating set, pump unit or lighting tower in the presence of animals (disturbance, scares, etc.).
- ✓ Engage the parking brake when the generating set or lighting tower on its trailer is installed on the operating site. When chocking the trailer on a slope; ensure that there is nobody in the path of the trailer.
- ✓ Never start the engine without an air filter or exhaust.
- ✓ Engine with turbocharger: never start the engine without fitting the air filter. The compressor wheel rotating inside the turbocharger may cause serious bodily injury. Foreign objects in the inlet pipe may cause mechanical damage.
- ✓ Engine with air preheating (starting components): never use a starting spray or any other similar starter assistance product. Upon contact with the starting component, an explosion may occur in the inlet tube, causing bodily injury.
- ✓ Do not touch the lighting column lights when they are switched on.

Maintenance

- ✓ Follow the maintenance table and its instructions.
- ✓ Always use tools in good condition which are suited to the work to be done. Ensure you have understood the instructions before beginning any operation.
- ✓ Goggles should be worn when carrying out maintenance operations and watches, bracelets etc. should be removed.
- ✓ Fit only original parts.
- ✓ Disconnect the battery and the pneumatic starter (if fitted) before undertaking any repairs, to prevent the engine from starting accidentally. Fit a panel over the controls to prevent any attempt to start.
- ✓ Only use the correct crankshaft turning techniques for turning the crankshaft manually. Do not try to turn the crankshaft by pulling it or levering the fan. This method may cause serious bodily or material damage, or damage the vanes of the fan, reducing the service life of the fan.
- ✓ Clean off any trace of oil, fuel or coolant using a clean cloth.
- ✓ Do not use a soapy solution containing either chlorine or ammonia, as these two chemicals prevent bubble formation.
- ✓ Never use petrol or other inflammable substances to clean the parts. Use only approved cleaning solvents.
- ✓ Do not use a high pressure cleaner for cleaning the engine and equipment. The radiator, hoses, electrical components, etc. may be damaged.
- ✓ Avoid accidental contact with parts at high temperatures (exhaust manifold, exhaust).
- ✓ Before any maintenance operation on a lighting column light, cut the electrical power supply and wait for the bulbs to cool down.

Consumables

- ✓ Observe regulations in force concerning use of fuel before using your generating set, pump unit or lighting tower.
- ✓ Under no circumstances use seawater or any other corrosive or electrolytic product in the cooling circuit.

Environment

- ✓ The operator must take the necessary measures to comply with the aesthetics of the site of use. The whole site must be maintained in a good state of cleanliness.
- ✓ The premises must be kept clean, and be regularly cleaned so as to avoid accumulation of dangerous materials or pollutants and dust, which could ignite or cause an explosion. The cleaning equipment must be suited to the risks posed by the products and dust.
- ✓ The presence of dangerous or combustible materials inside premises housing combustion devices shall be limited to the operating requirements.
- ✓ Facilities must be operated under the constant supervision of a qualified person, who must regularly check that the safety devices are operating correctly and ensure that the combustion devices have the correct fuel supply.
- ✓ Apart from the combustion devices, it is prohibited to use fire in any form. This restriction must be clearly displayed.

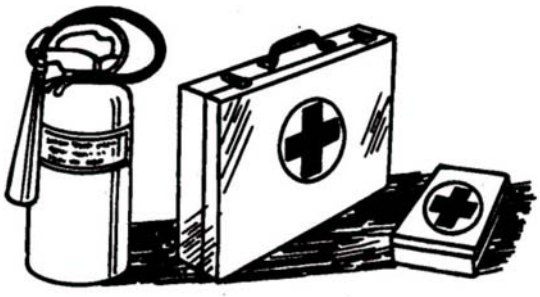
- ✓ Spreading of waste water, sludge and waste is prohibited.
- ✓ The fuels to be used must correspond to those featured in the declaration file and the specifications recommended by the combustion device manufacturer.
- ✓ The fuel is considered to remain in the same physical state as when it is introduced into the combustion chamber.
- ✓ Burning of waste in the open air is prohibited.
- ✓ Always protect your hands when checking for leaks. Pressurised liquids may penetrate body tissue and cause serious damage. Risk of blood contamination.
- ✓ Drain and dispose of engine oil in a specially provided container (fuel distributors can collect your used oil).
- ✓ Except by special agreement, once closed, the gas supply main unit must only be re-opened by the gas distributor. However, the user may access it under certain conditions. Check these for each site.

1.3.2 Risks related to exhaust gases and fuels

	The carbon monoxide present in exhaust gases may cause death if the concentration levels in the air breathed are too high. Always use generating sets, pump units or lighting towers in a well-ventilated place where gases cannot accumulate. In case of indoor use: ✓ Be sure to evacuate exhaust gases outdoors. ✓ Provide appropriate ventilation so that personnel present are not affected.
Danger	

- ✓ Observe the local regulations in force for generating sets, pump units or lighting towers, as well as local regulations for use of fuel (petrol, diesel fuel and gas) before using your generating set, pump unit or lighting tower.
- ✓ Fuel filling should be carried out when the engine is off (except for generating sets with an automatic filling system).
- ✓ Engine exhaust gases are toxic: do not run the generating set, pump unit or lighting column in unventilated premises. If installed in a ventilated room, additional requirements for fire and explosion protection must be observed.
- ✓ A leaking burnt gas exhaust may increase the sound level of the generating set, pump unit or lighting column. To check on its efficiency, regularly examine the burnt gas exhaust.
- ✓ Pipes must be replaced as soon as their condition demands it.

1.3.3 Risks related to toxic products

	The corrosion inhibitor contains alkali. Do not swallow it. This substance should not come into contact with the eyes. In the event of contact with the eyes, rinse immediately with plenty of water for at least 15 minutes. Avoid prolonged or repeated contact with the skin. In the event of contact with the skin, wash thoroughly with water and soap. CONSULT A DOCTOR IMMEDIATELY. KEEP THE PRODUCT OUT OF THE REACH OF CHILDREN**.** The anti-rust product is toxic and dangerous if absorbed. Avoid all contact with the skin and eyes. Read the instructions on the packaging.	Glycol is a toxic product and dangerous if absorbed. Avoid all contact with the skin and eyes. Read the instructions on the packaging. 
Warning		

- ✓ Caution: fuels and oils are dangerous to inhale. Ensure proper ventilation, and use a protective mask.
- ✓ Never expose the equipment to liquid splashes or rainfall, and do not place it on wet ground.
- ✓ The battery electrolyte is harmful to skin and especially eyes. If splashes get into eyes, rinse immediately with running water and/or a 10% diluted boric acid solution**.**
- ✓ Wear protective eyewear and strong base resistant gloves for handling the electrolyte.

1.3.4 Risk of fire, burns and explosion

Danger	The engine should not be operated in environments containing explosive products. As not all of the electrical and mechanical components are shielded, there is a risk of sparks forming.

- ✓ Make sure not to create sparks or flames, and not to smoke near the batteries, as the electrolyte gases are highly flammable (especially if the battery is charging). Their acid also poses a risk to the skin, and in particular to the eyes.
- ✓ Never cover the generating set, pump unit or lighting tower with any material during operation or just after shutdown (wait for the engine to cool).
- ✓ Do not touch hot parts such as the exhaust pipe, or put combustible materials on it.
- ✓ Keep all flammable or explosive materials (e.g. petrol, oil, cloth, etc.) out of the way when the set is running.
- ✓ Proper ventilation is required for your generating set, pump unit or lighting column to work properly. Without this ventilation, the engine would very quickly rise to an excessively high temperature, causing accidents or damage to the equipment and to surrounding property.
- ✓ Do not remove the radiator cap if the engine is hot and the coolant is pressurised, due to risks of burns.
- ✓ Depressurise the air, oil and cooling circuits before removing or disconnecting all the fittings, pipes or connected components. Watch out for the possible presence of pressure when disconnecting a device from a pressurised system. Do not try to find pressure leaks by hand. Oil at high pressure can cause bodily damage.
- ✓ Some preservative oils are flammable. Also, some are dangerous to inhale. Ensure proper ventilation. Use a protective mask.
- ✓ Hot oil causes burns. Avoid contact with hot oil. Check that the system is no longer pressurised before carrying out any procedures. Never start or run the engine with the oil filler cap off (oil may splash out).
- ✓ Never coat the generating set, pump unit or lighting column with a thin layer of oil to protect it from rust.
- ✓ Never top up the oil or coolant if the generating set, pump unit or lighting column is running, or if the engine is hot.
- ✓ A generating set can only operate when stationary, and cannot be installed on a vehicle or other mobile equipment, without a prior study taking into account the various specific features of using the generating set.

1.3.5 Risks related to electrical networks

- ✓ The electrical equipment supplied with the generating set complies with standard NF C15.100 (France), or with the standards of the countries in question.
- ✓ The earth connection must be installed in accordance with the standards in force in each country in question, and with the neutral system sold.
- ✓ Read the manufacturer's identification plate carefully. The values for voltage, power, current and frequency are shown. Check that these values match the supply use.
- ✓ Never accidentally touch stripped cables or loose connections.
- ✓ Never handle a generating set with wet hands or feet.
- ✓ Maintain electrical wires and connections in good condition. Using equipment in poor condition can lead to electrocution and damage to equipment.

- ✓ Always disconnect the power to the equipment or facility (generating set voltage, battery voltage and network voltage) before any operation.
- ✓ The electrical connections must be made in accordance with current standards and regulations in the country of use.
- ✓ Do not use faulty, poorly insulated or provisionally connected wires.
- ✓ Never reverse the positive and negative terminals on batteries when connecting them. This could cause severe damage to the electrical equipment. Follow the wiring diagram supplied by the manufacturer.
- ✓ The generating set should not be connected to any other power sources, such as the mains supply network. In specific cases where there is to be a connection to existing electrical networks, this must only be installed by a qualified electrician, who should take the operating differences of the equipment into account, according to whether the mains supply network or generating set is being used.

- ✓ Protection against electric shocks is ensured by an assembly of specific equipment. If this needs to be replaced, it should be by components with identical nominal values and specifications.
- ✓ If the protective plates (blanking covers) need to be removed to route cables, the protector (blanking cover) must be refitted when the operations are finished.
- ✓ Due to high mechanical stresses, use only strong flexible wiring with rubber sheathing, compliant with IEC 245-4, or equivalent wiring.

1.3.6 Dangers presented by electric currents (first aid)

First aid

In the event of an electric shock, shut off the power immediately and activate the emergency stop on the generating set or lighting column. If the voltage has not yet been cut off, move the victim out of contact with the live conductor as quickly as possible. Avoid direct contact both with the live conductor and the victim's body. Use a dry plank of wood, dry clothes or other non-conductive materials to move the victim away. The live wire may be cut with an axe. Take great care to avoid the electric arc that will be generated by this.

Begin emergency procedures

Resuscitation

If breathing has stopped, begin artificial respiration at once in the same place the accident took place unless the victim or operator's life could be endangered by this.
In the event of cardiac arrest, carry out cardiac massage.

1.3.7 Risks related to moving the set

To unload the generating sets, pump units or lighting columns from their transport support brackets under optimum safety and efficiency conditions, you must ensure that the following points are observed:

- ✓ The lifting machinery or equipment is suited to the work required, in good condition and with sufficient lifting capacity.
- ✓ The slings are positioned in the rings provided for this operation, the forklift arms are resting fully underneath all of the base frame cross-beams, or the lifting bars are inserted in the apertures provided for this purpose in the base to lift the entire generating set (according to models).
- ✓ For completely safe working conditions and to prevent damage to the components fitted on the upper edge of the set, pump unit or lighting column, the generating set, pump unit or lighting column must be lifted up with an adjustable boom. All the chains and cables must be parallel with each other, and as perpendicular as possible with the upper edge of the generating set, pump unit or lighting column.
- ✓ If other equipment fitted on the generating set, pump unit or lighting column alters its centre of gravity, special lifting devices may be necessary to maintain correct balance and completely safe working conditions.
- ✓ The ground must be able to withstand the load of the generating set, pump unit or lighting column and its lifting machinery without stress (otherwise, put down beams of sufficient strength in a stable configuration).
- ✓ Position the generating set, pump unit or lighting column as close as possible to its place of use or transport, in a clear space with free access.
- ✓ Never perform work on a generating set, pump unit or lighting tower just hanging from a lifting device.

1.3.8 Risks related to noise

	Dangerous noise **Risk of hearing loss**
Important	

Prolonged exposure to a noise level above 80dB (A) can lead to permanent hearing damage**.**
Therefore, it is recommended that ear defenders are used when working in close proximity to a generating set which is in operation.

2. General description

Overview

Figure 2.1.1 : General description of the generating set

1	Acces to maintenance area	4	Acces to control unit
2	Lifting ring	5	Acces to power connections
3	Forklift grooves	6	Drawbar

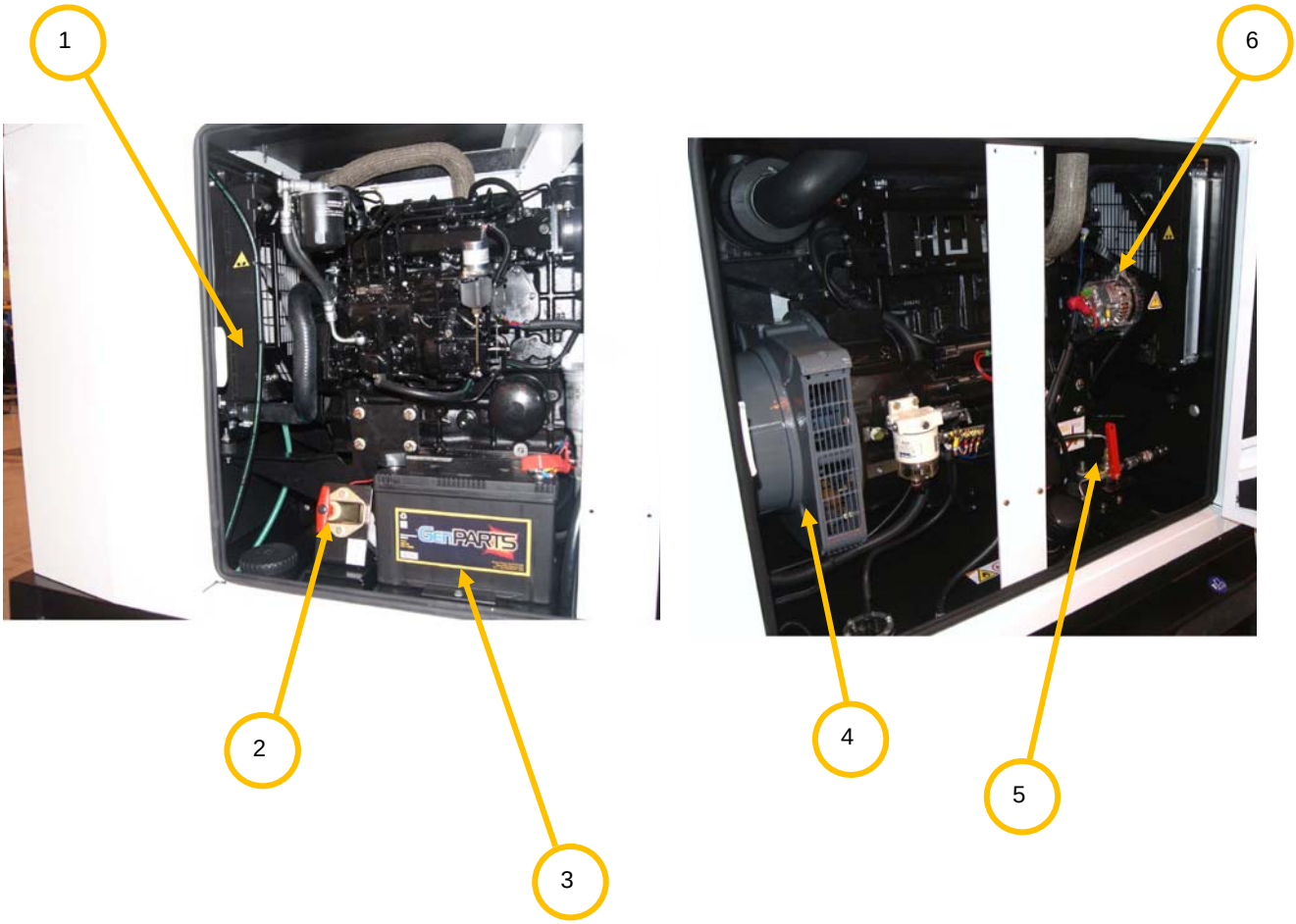


Figure 2.1.2 : General description of the generating set

1	Protective grille	4	Alternator
2	Battery isolating switch	5	External fuel supply combined tap (optional)
3	Starter battery	6	Charging alternator

Control

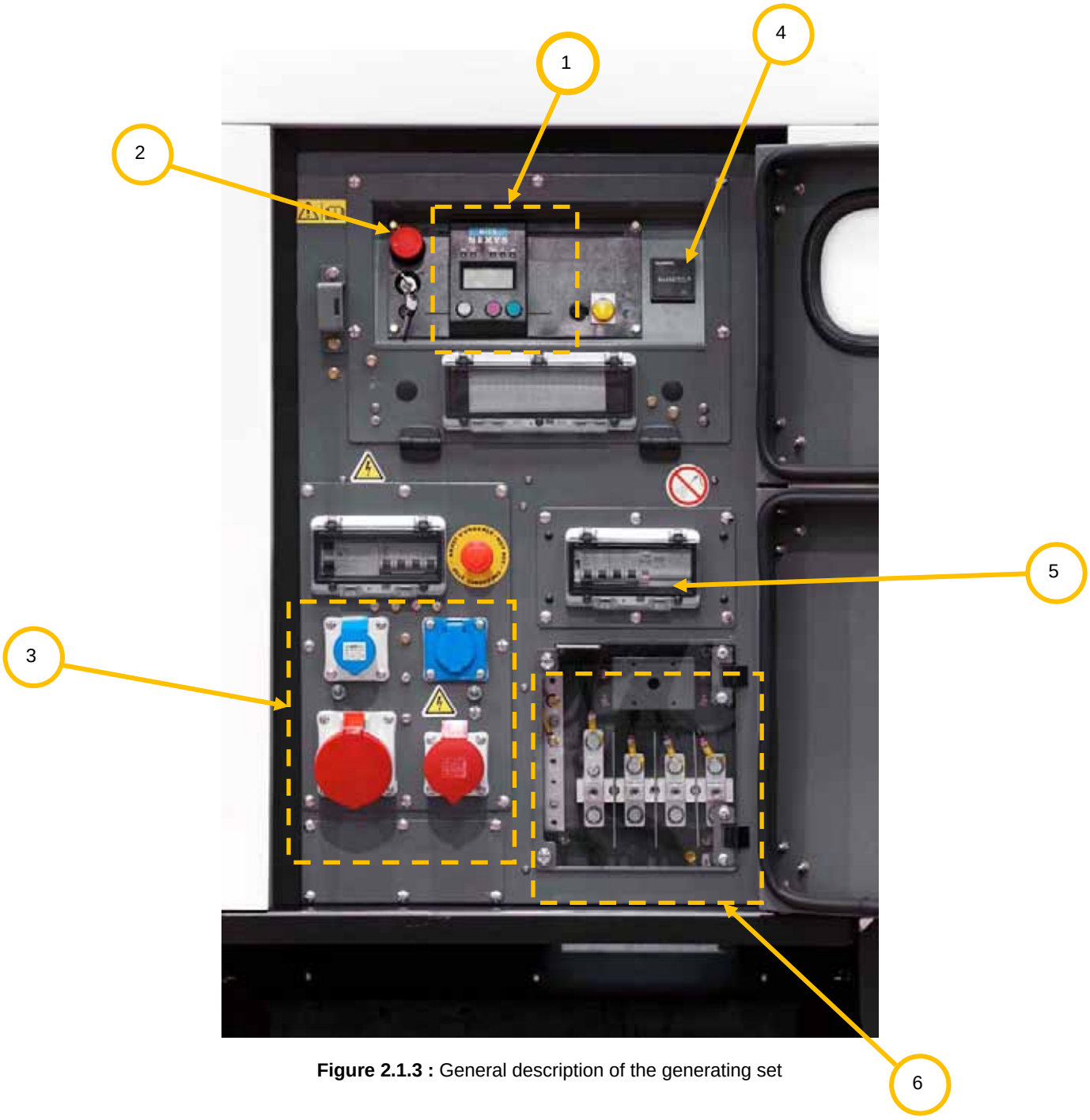


Figure 2.1.3 : General description of the generating set

1	Control unit	4	Working hours counter
2	Emergency stop	5	Power circuit breaker
3	Socket control panel	6	Connection terminal block

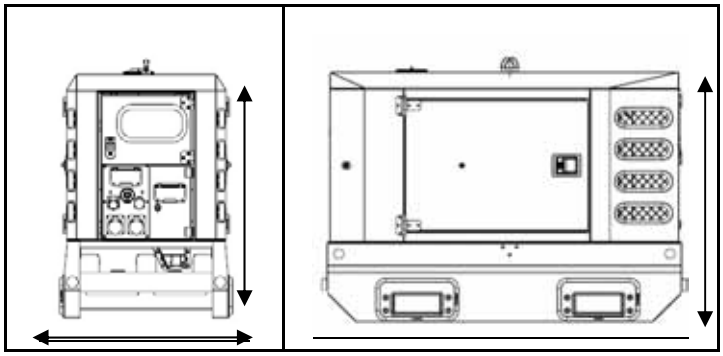
Note : Photo presented with the Nexys control unit.

2.1. Technical specifications

Range / Generating set type	RENTAL POWER / R44C3

Weights and Dimensions

Dimensions with high autonomy tank



Dimensions l x w x h
2200 mm x 1000 mm x 1528 mm

Weight:
1150 kg dry weight / 1350 kg in operating configuration

Hood:
M3127
Sound pressure level:
at 1 m: 73 dB(A)
measurement uncertainty : 0.70

Output

Voltage	Hz	Phase	Load factor	Max current (A)	Emergency power [1] kW / kVA	Prime power [2] kW / kVA
400/230	50	3	0.8	58	32 / 40	29 / 36

(1) ESP: Stand-by output available for emergency use under variable charge up to 200hrs per year as per ISO 8528-1, no overload available under these service conditions.

(2) PRP: Main output available continuously under variable load for an unlimited time period per year as per ISO 8528-1, an overload of 10% one hour every 12 hours is available, as per ISO 3046-1.

- Term of use :

Standard reference conditions ESP/PRP 40° / 40°, Air Intlet Temp, 1000m / 1000m mA.S.L. 60 % relative humidity.

Engine data	
Manufacturer / model	MITSUBISHI S4S-Z3DT61SD
Type	4 Cycles Naturally aspirated
Cylinder configuration	4 XL
Cubic capacity	3.33 L
Rotation speed	1500 Rpm
prime power at nominal speed	36 kW
Adjustment type	Mechanical

Fuel consumption	
100 % main power	10.4 L/h

Fuel	
Fuel type	Diesel
High autonomy fuel tank	220 L

Lubrication	
Oil capacity	10 L
Min. Oil pressure	1 bar
Nominal oil pressure	3.9 bar
Oil consumption (100 % load)	0.11 L/h
Oil sump capacity	9 L
Type of lubricant	Genlub

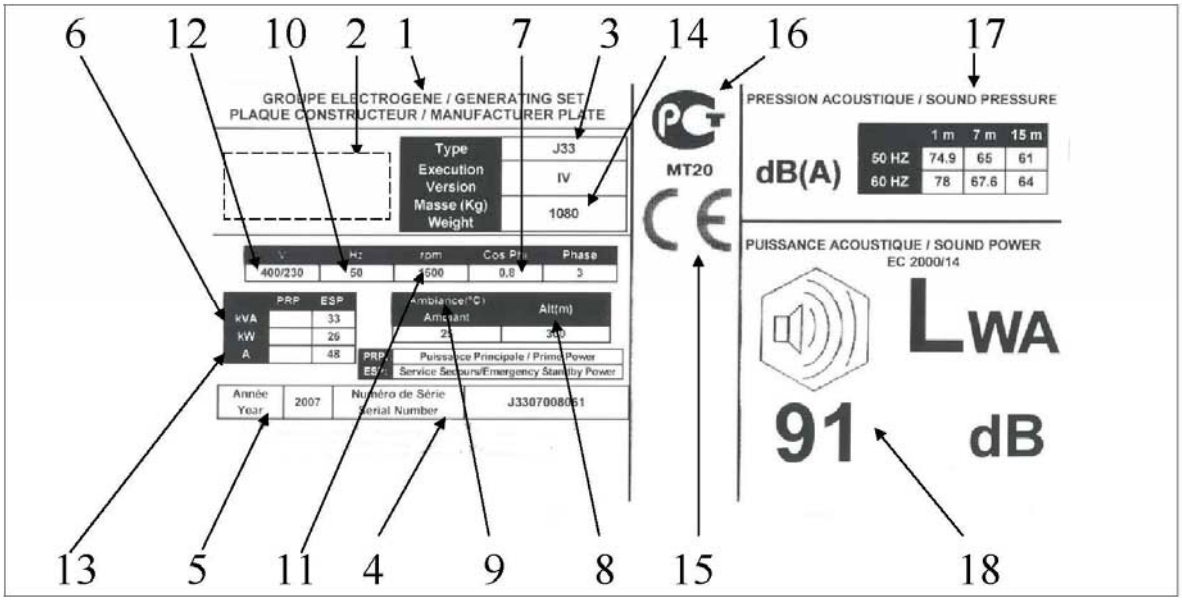
Cooling	
Engine capacity with radiator	9.5 L
Max coolant temperature	102 °C
Fan power	0.8 kW
Refrigerant type	Gencool
Thermostat	76.5 – 90 °C

Alternator data	
● Compliant with NEMA MG21 standards, UTE NF C51 111, VDE 0530, BS 4999, IEC 34.1, CSA	● The alternator is protected against short circuits ● Vacuum impregnation, epoxy winding, IP23 protection rating
Type	LEROY SOMER LSA43.2S159
Number of phases	3
Power factor (cos Phi)	0.8
Number of poles	4
Excitation type	AREP
Insulation classe	H
Number of bearings	1
Coupling	Direct

Control unit(s)	
NEXYS 	<u>Standard specifications</u>: Frequency meter, Voltmeter, Ammeter <u>Alarms and faults</u>: Oil pressure, Coolant temperature, Fail to start, Overspeed, Alternator min/max, Fuel level low, Emergency shutdown <u>Engine parameters</u>: Working hours counter, Engine speed, Battery voltage, Fuel Level, Air Preheating
TELYS 	<u>Standard specifications</u>: Voltmeter, Ammeter, Frequency meter <u>Alarms and faults</u>: Oil pressure, Water temperature, Start failure, Overspeed, Alternator min/max, Battery voltage min/max, Emergency stop <u>Engine parameters</u>: Timer, Oil pressure, Water temperature, Fuel level, Engine speed, Battery voltage

2.2. Identifying sets

Generating sets and their components are identified by means of identification plates.
The precise rules for identifying each major component (engine, alternator etc.) are set out in each manufacturer's documentation contained in the appendices of this manual.



1 - Generating set 2 - Manufacturer name 3 - Model 4 - Serial number 5 - Year of manufacture 6 - Rated output (kVA and kW) according to the ISO 8528-1 standard PRP: main power ESP: emergency power 7 - Rated power factor 8 - Maximum altitude of the site above sea level (m) for the rated power	9 - Maximum ambient temperature for the rated power (°C) 10 - Rated frequency (Hz) 11 - Generating set rotation speed (RPM) 12- Rated voltage (V) 13 - Rated current (A) 14 - Weight (kg) 15 - CE marking 16 - Non CE standard marking e.g.: GOSSTANDART) 17 - Sound pressure 18 - Sound power

Figure 2.2: Example of generating set identification plate

2.3. Fluid retention

Any outflow of the fluids contained in the generating sets (fuel, oil and coolant, or rainwater or condensation) will be collected in a retention container.
The containers have a capacity which allows 110% of the fluids contained in the generating set fitted with this option to be collected.

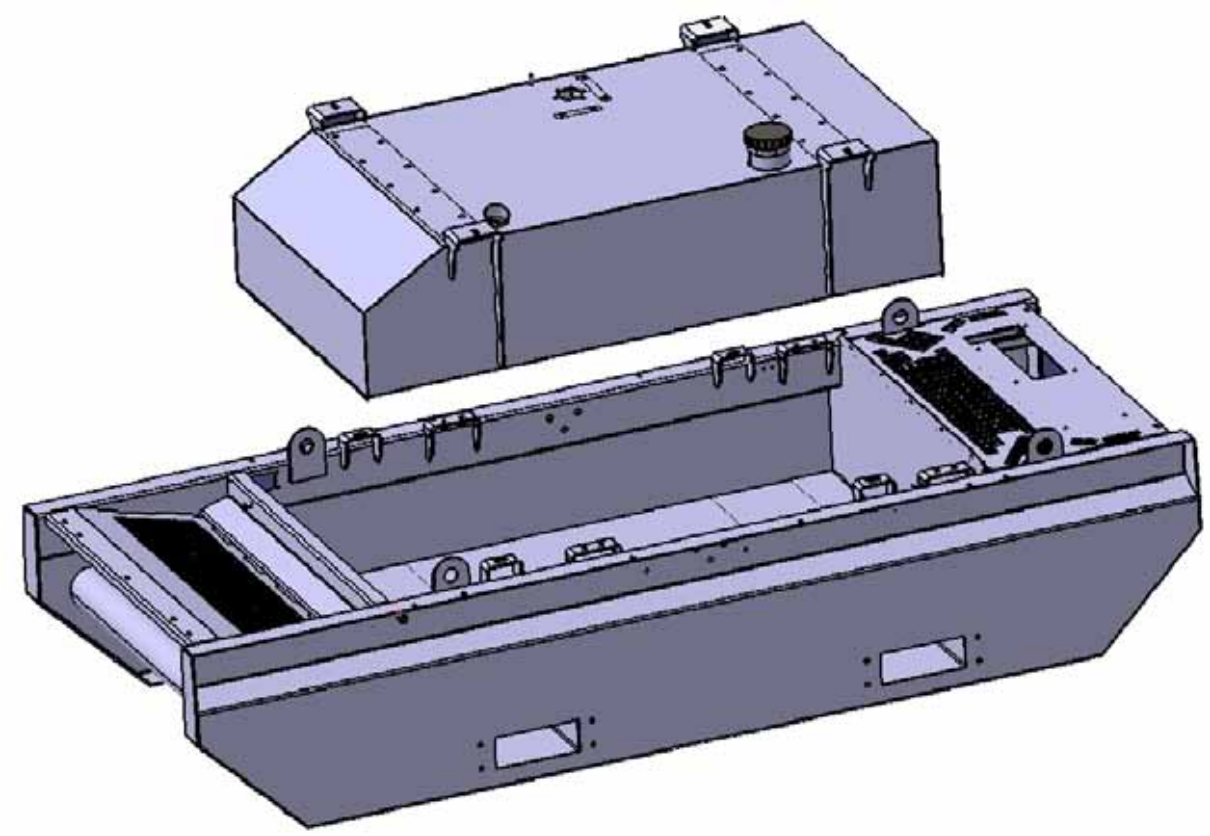


Diagram 2.3: Fluid retention container

The generating sets are fitted with a visual alarm warning when the upper limit of the retention container has been reached.

In all cases, the retention containers must be regularly checked to ensure they contain no fluid (fuel, oil and coolant, or rainwater or condensation). If necessary, drain the containers via the drain port.

- ✓ **Note**: Never allow these fluids to drain onto the ground; ensure they are collected in a designated container.

2.4. Fuel and consumables

All specifications (product features) are given in the engine maintenance manuals attached to this manual.

Fuels:
The specifications refer to European or international standards. Fuels complying with the standards indicated in the engine maintenance manuals can be used without any contraindications. Only these fuels may be used.

Consumables:
In addition to the specifications indicated in the engine maintenance manuals, the consumables mentioned in the section entitled "Specifications" are recommended.

2.4.1 Specifications

2.4.1.1. Oil grades

Engine		Oil	
Make	Type	Make	Type
John Deere	All	John Deere	John Deere PLUS-50
		GenPARTS	GENLUB TDX 15W40
MITSUBISHI	All	GenPARTS	GENLUB TDX 15W40
Volvo	All	GenPARTS	GENLUB TDX 15W40

GENLUB TDX 15W-40
Top-of-the-range lubricant recommended for diesel engines: for generating sets used under severe conditions.

USES:

- ✓ Particularly suited to more modern engines with or without turbochargers, *intercoolers*, or sophisticated injection systems (e.g. ***HEUI*****,** injector-pumps).
- ✓ **All types of use**: can cope with the most demanding applications.
- ✓ **Depolluted engines:** complies with EURO 2 and EURO 3 technology and can be used with all types of diesel fuel, especially ecological diesel with low sulphur content.

PERFORMANCE:

ACEA E3
API CH-4

- ✓ Meets level E3 of the specifications defined by European manufacturers in the ACEA standards 98 edition.

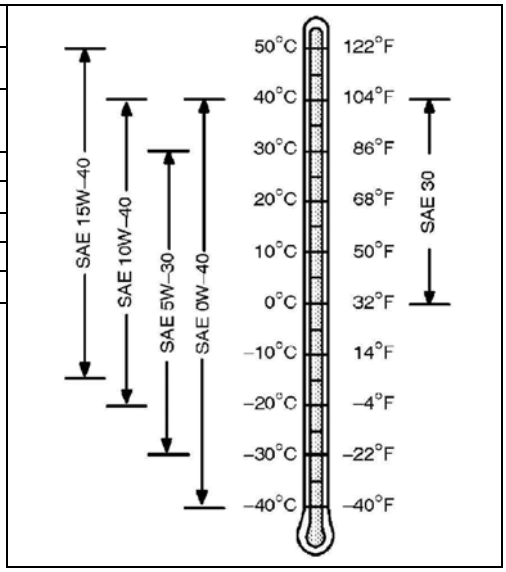
ADVANTAGES:

- ✓ **Less frequent oil services**: this product has been put to the test during thousands of hours of use on worksites under varying conditions, demonstrating its high quality.
- ✓ **Conformity with new environmental legislation**: adherence to new anti-pollution standards required for new EURO 2 and EURO 3 engines.

SPECIFICATIONS:

SAE Grade	**15W-40**	
Density at 15°C	0.883	
Cinematic viscosity at 40 °C Cinematic viscosity at 100 °C	105 14.1	mm2/s (cSt) mm2/s (cSt)
Viscosity index	140	
Dynamic viscosity at -15 °C	3000	mPa.s(cP)
Pour point	- 30	°C
Flash point	220	°C
Sulphated ash content	1.4	% weight

(Values given as examples only)



2.4.1.2. Specifications of coolants

Engine		Coolants	
Make	Type	Make	Type
John Deere	All	GenPARTS	GENCOOL PC -26°C
MITSUBISHI	All	Mitsubishi	LLC
		GenPARTS	GENCOOL PC -26°C
Volvo	All	GenPARTS	GENCOOL PC -26°C

GenCOOL PC -26
High-protection coolant, approved by manufacturers.
GenCOOL PC -26 is a ready-to-use, highly protective coolant which is produced from an antifreeze recommended by the majority of European manufacturers.

- It is made from antifreeze and G 48 inhibitors.
- It protects up to -26°C.
- It is free from nitrates, amines and phosphates.
- It is a clear, fluorescent orange liquid.

REFERENCES/APPROVALS (for the antifreeze):

HEAVY GOODS VEHICLE	LIGHTER VEHICLES
Approved by MTU, MERCEDES BENZ, MAN, KHD, GENERAL MOTORS Conforms with VOLVO, IVECO, VAN HOOL and STAYR TRUCK specifications	Approved by BMW, VOLKSWAGEN, MERCEDES, PORSCHE Conforms with VOLVO, OPEL, SEAT and SKODA specifications

Conforms with the NF R 15.601 standard

REINFORCED ANTI-CORROSION FEATURES:

- Protects **against high-temperature corrosion** by oxidisation of ethylene (cylinder head protection).
- Protects **against high-temperature cavitation** (top of cylinder and coolant pump protection).
- Non-corrosive for seals and hoses.
- Improves the **efficiency and longevity of the cooling system.**
- **GenCOOL PC -26** is especially recommended for engines fitted with aluminium or light alloy radiators.

HIGH TEMPERATURE SUITABILITY:

- Provides good conditions for thermal exchange.
- Perfect stability at high temperatures.
- **GenCOOL PC -26** is specially adapted for engines with high power densities.

LONG LASTING PROTECTION:

- High alkaline reserve/stability and longevity of corrosion inhibitors.
    - Maintains its technical properties during prolonged use at high temperatures (neutralisation of acids).
- Ensures maximum heat transfer without the build up of deposits in the cooling system.
- **GenCOOL PC -26** ensures optimum protection against overheating and corrosion in extreme conditions of vehicle use.

PACKAGING/STORAGE:

- **GenCOOL PC -26** is supplied in 210 l metallic barrels with smooth interior linings.
- It can be stored for 2 years in its original container and packaging.
- Avoid zinc coated containers.

RECOMMENDATIONS FOR USE:

- Compatible with the original fluid.
- It is recommended that the cooling system is completely drained when replacing the fluid.

SPECIFICATIONS	UNITS	SPECIFIED VALUES	TRIAL METHODS
Density at 20°C	kg/m^3	**1,059 +/- 3**	R 15-602-1
pH	pH	**7.5 to 8.5**	NF T 78-103
Alkalinity reserve	ml	**>=10**	NF T 78-101
Boiling point	°C	**105 +/- 2**	R 15-602-4
Freezing point:	°C	**-26 +/- 2**	NF T 78-102
Glassware corrosion : (test with antifreeze)	mg/test piece		R 15-602-7
- Copper		**+/- 2.6**	
- Weld		**+/- 0.5**	
- Brass		**+/- 2.3**	
- Steel		**+/- 1.6**	
- Cast iron		**+/- 0.8**	
- Cast aluminium		**+/- 1.0**	
Corrosion on warm plate (test with antifreeze)	mg/(cm²week)	**+/- 0.17**	R 15-602-8

3. Installation-Connections

3.1. Unloading

3.1.1 Safety during unloading

To unload electrical generating sets from their transport supports with optimum safety and efficiency, you must ensure that the following points are observed:

- The lifting machinery or equipment is suitable for the work required.
- The sling is correctly positioned in the central lifting eye or the lifting arms are correctly positioned in the fork-lift pockets intended for this purpose.
- The ground is able to bear the load of the generating set and its lifting machinery without stress (otherwise lay down stabilising beams of sufficient strength).
- The generating set is put down as close as possible to its place of use or transport, in a clear space with free access.

Example of equipment to be used:

- ✓ crane, slings, lifting beam, safety hook, shackles.
- ✓ Forklift truck.

3.1.2 Instructions for unloading

Hoisting

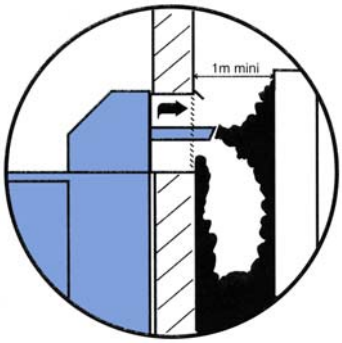
1. Attach the sling on the lifting equipment to the ring on the generating set (no. 1) provided for this purpose. Tension the slings slightly.
2. Check that the sling is correctly attached and the equipment is steady.
3. Lift the generating set carefully.
4. Direct the generating set towards the chosen location and stabilise it.
5. Carefully set down the equipment while continuing to position it.
6. Release the sling, then detach it.

Forklift truck:

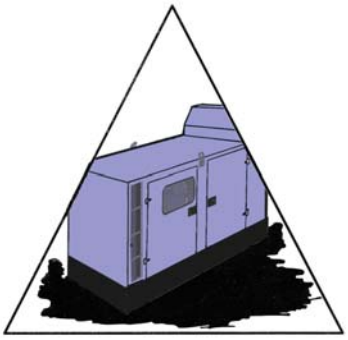
1. Position the arms of the forklift truck in the forklift pockets (no. 2).
2. Lift the equipment, handling it gently.
3. Set down the generating set in its unloading position.

3.2. Choice of location

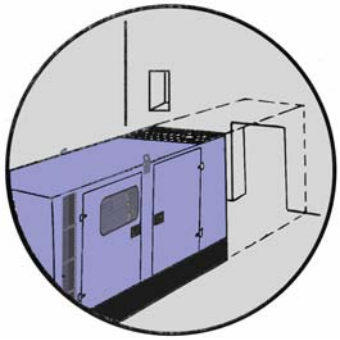
This shall be determined according to the application. There are no strict rules governing the choice of location, other than the proximity of the electrical supply panel and the disturbance caused by the noise. However, it is important to take into account the fuel supply, the evacuation of burnt gases, the direction of these gases and evacuation noises.
The choice of location will therefore be the result of a carefully considered compromise!
Examples of problems that may be encountered:



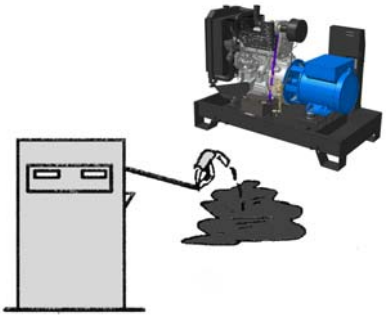
Incorrect ventilation and exhaust



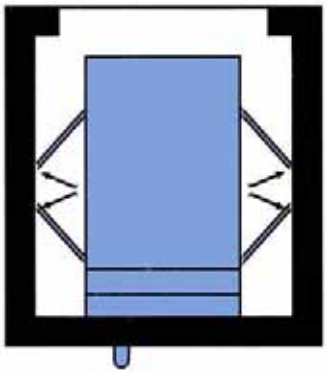
Building or terrain too rough.
Generating set incorrectly seated



Reduced access



Impossible to fill with fuel



Impossible to open enclosure doors

Figure 3.1: Examples of problems that may be encountered

Warning	**Ensure that the generating set is placed on a flat surface.**

3.3. Moving the genset

Whenever the generating set is moved, the appropriate equipment must be used (sling, forklift, etc.) and you must know the parts of the generating set which enable it to be moved (see below).

❶ Central lifting ring

❷ Forklift pockets

❸ Drawbars

3.4. Connections

3.4.1 Connections - general information

As with low voltage electrical installations, use and maintenance is governed by standard NFC 15.100 (France) or by the standards in the relevant country, based on international standard IEC 60364-6-61.
They must also adhere to the regulations in the NFC 15.401 application guide (France) or to the regulations and standards in the relevant country.

3.4.2 Power cables

These can be unipolar or multipolar according to the power of the generating set.
Power cables should preferably be installed in ducts or on a cable tray for this purpose.
The cable cross-section and number of cables should be determined according to the cable type and the current standards to be observed in the country of installation. The choice of conductors must comply with international standard IEC 30364-5-52.

Three phase - Calculation hypothesis
Fitting method = wiring in cable runs or non perforated trays.
Permissible voltage drop = 5%
Multiconductors or single conductor joined when precision 4X…(1)
Cable type PVC 70°C (e.g. H07RNF).
Ambient temperature = 30°C.

Circuit breaker calibre (A)	Cable sizes		
	0 - 50m	51 - 100m	101 - 150m
	mm²/AWG	mm²/AWG	mm²/AWG
10	1.5 / 14	2.5 / 12	4 / 10
16	2.5 / 12	4 / 10	6 / 9
20	2.5 / 12	4 / 10	6 / 9
25	4 / 10	6 / 9	10 / 7
32	6 / 9	6 / 9	10 / 7
40	10 / 7	10 / 7	16 / 5
50	10 / 7	10 / 7	16 / 5
63	16 / 5	16 / 5	25 / 3
80	25 / 3	25 / 3	35 / 2
100	35 / 2	35 / 2	4X(1X50) / 0
125	(1) 4X(1X50) / 0	4X(1X50) / 0	4X(1X70) / 2/0
160	(1) 4X(1X70) / 2/0	4X(1X70) / 2/0	4X(1X95) / 4/0
250	(1) 4X(1X95) / 4/0	4X(1X150) / 2350MCM	4X(1X150) / 2350MCM
400	(1) 4X(1X185) / 0400MCM	4X(1X185) / 0400MCM	4X(1X185) / 0400MCM
630	(1) 4X(2X1X150) / 2x 2350MCM	4X(2X1X150) / 2x 2350MCM	4X(2X1X150) / 2x 2350MCM

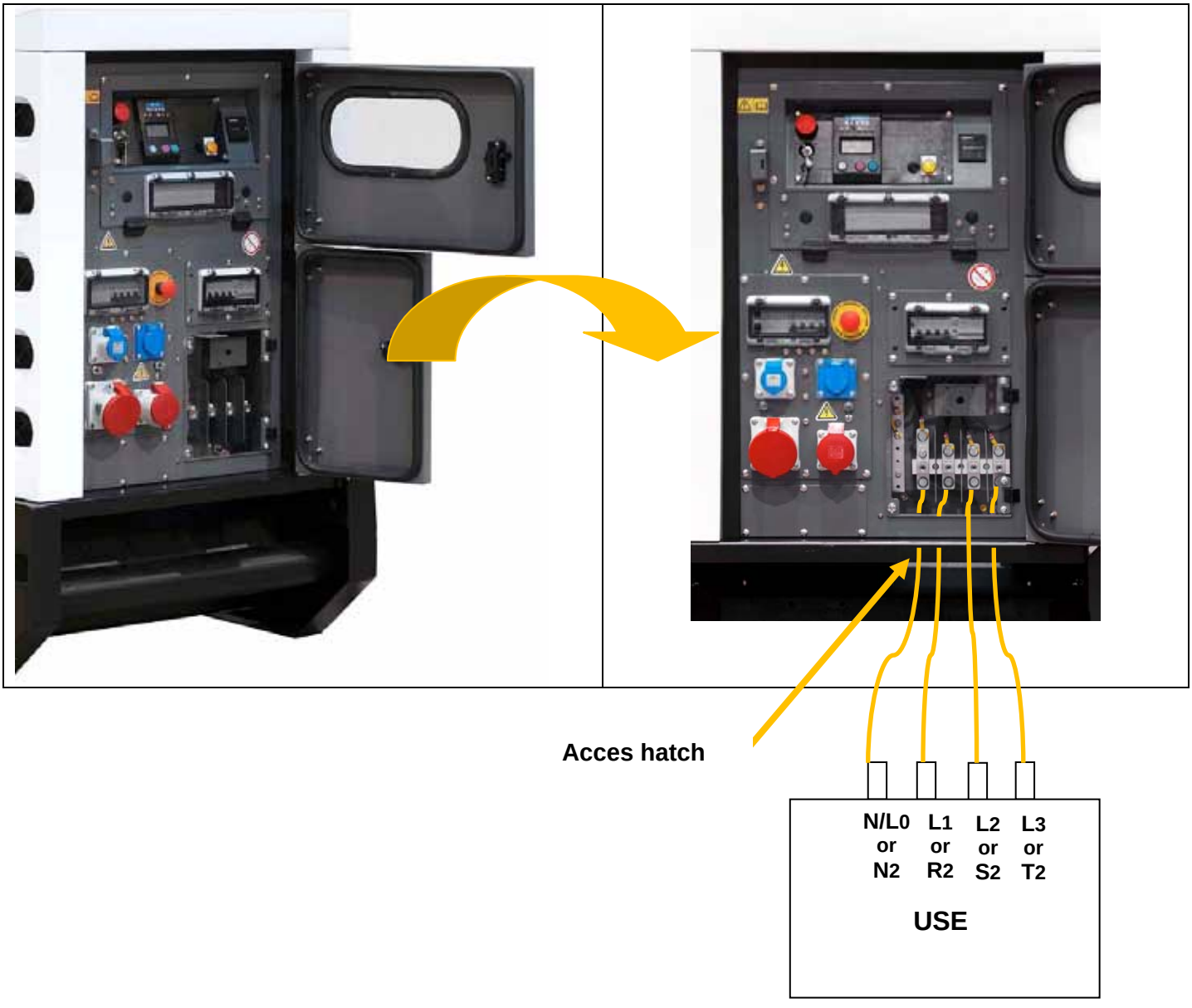
Single phase - Calculation hypothesis
Fitting method = wiring in cable runs or non perforated trays.
Permissible voltage drop = 5%
Multiconductors.
Cable type PVC 70°C (e.g. H07RNF).
Ambient temperature = 30°C.

Circuit breaker rating (A)	Cable sizes		
	0 - 50m	51 - 100m	101 - 150m
	mm²/AWG	mm²/AWG	mm²/AWG
10	4 / 10	10 / 7	10 / 7
16	6 / 9	10 / 7	16 / 5
20	10 / 7	16 / 5	25 / 3
25	10 / 7	16 / 5	25 / 3
32	10 / 7	25 / 3	35 / 2
40	16 / 5	35 / 2	50 / 0
50	16 / 5	35 / 2	50 / 0
63	25 / 3	50 / 0	70 / 2/0
80	35 / 2	50 / 0	95 / 4/0
100	35 / 2	70 / 2/0	95 / 4/0
125	50 / 0	95 / 4/0	120 / 2250MCM

3.4.3 Power connections

Warning	**Disconnect the battery leads or use the battery isolating switch before carrying out any operations on the generating set.** (To disconnect the battery, disconnect the negative lead (-) first).

1. Open the access hatch to the power section.
2. Feed the power cables through the access hatch on the genset control unit.
3. Connect the power cables to the bars. (N/L0-L1-L2-L3 or N2-R2-S2-T2).
4. Connect the power cables to the installation ensuring the live and neutral wires are correctly connected.



Warning	**Ensure that the direction of rotation of the phases is identical on the genset and the installation.** (Our gensets are factory-set with a conventional direction of phase rotation)

3.4.4 Battery installation

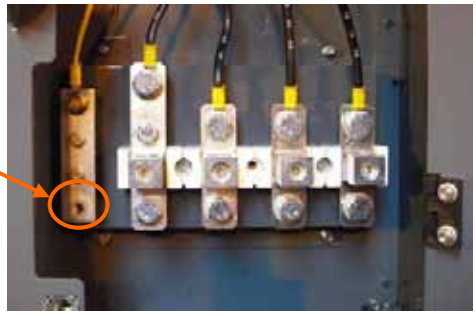
Install the battery or batteries in the immediate vicinity of the electric starter motor. The cables will be connected directly from the battery terminals to the starter motor terminals.
The primary instruction to follow is to ensure that the polarities between the battery and starter motor match. Never reverse the positive and negative battery terminals when connecting them. This could cause severe damage to the electrical equipment.
The minimum cross-section of the cables will be 70 mm^2. It varies according to the power of the starter motor but also the distance between the batteries and the set (voltage drops on the line).

3.5. Protection for individuals and equipment

3.5.1 Earth connection

For effective protection against electric shocks, the generating set needs to be earthed. To do this, use a copper wire, with a minimum cross-section of 25 mm^2 for a stripped cable and 16 mm^2 for an insulated cable, connected to the generating set earth socket and a galvanised steel earthing rod embedded vertically into the ground.

generating set earth socket



The earthing rod resistance value should comply with the values shown in the table below.
Note: use the highest differential setting from the installation as a guideline.

The resistance value is calculated in the following way: $R = \frac{Ul}{I\,\Delta n}$

Maximum resistance value of the earth socket R (Ω) according to the differential unit operational current (operation time should not be longer than 1 second).

I Δn differential	Earth R (Ω) Ul: 50 V	Earth R (Ω) Ul: 25 V
≤ 30 mA	500	> 500
100 mA	500	250
300 mA	167	83
500 mA	100	50
1A	50	25
3A	17	8
5A	10	5
10A	5	2.5

The Ul value: 25 V is required for work site installations, and livestock buildings, etc.

For a default voltage of 25 V and a default current of 30 mA, this rod must be of a minimum length of: see table below

Nature of ground	Length of rod in metres	
Thick arable land, moist compact ballast	1	
Lean arable land, Gravel, coarse ballast	1	
Bare stony soils, dry sand, impermeable rock	3.6	To obtain an equivalent length, you can use several earthing rods connected in parallel and set apart by at least their length. Example: 4 interconnected 1 metre rods separated by 1 metre.

Note: For the United States (National Electrical Code reference NFPA-70).
The generating set must be earthed. To do this, use a copper wire with a minimum cross-section of 13.3 mm² (or AWG 6, at most) connected to the generating set earth socket and a galvanised steel earthing rod fully embedded into the ground vertically.
This earthing rod embedded fully in the ground must have a minimum length of 2.5 m.

3.5.2 Earthing system principle

The **Earthing system**, or **SLT** (formerly **Neutral system**) of the electrical facility defines the situation of the generating set neutral in relation to earth and the grounds of the electrical facility at the user end.

The purpose of the earthing systems is to protect personnel and equipment by managing risks posed by insulation defects. For safety reasons, any live conducting part of a facility must be insulated from the earth. This insulation may be achieved by distance, or by using insulating materials. But with time, insulation may deteriorate (due to vibrations, mechanical impacts, dust, etc.), and therefore generate an earth with dangerous potential. This defect poses risks for personnel and property, but also continuity of service.

Earthing systems are codified by two letters that define the connections:
✓ The first letter defines the neutral connection:

I	Insulated or earthed via an impedance device
T	Connected to earth

✓ The second letter defines the grounding situation of the electrical facility:

T	Connected to earth
N	Connected to neutral

E.g.: IT = Isolated Neutral + Ground earthed

Speed		Number of conductors	Detection	Note
TT		4 poles	Measurement of residual current	Triggering of 1st fault by RCD
TN	C	3 poles	No measurement of residual current	Triggered by overcurrent protection upon 1st fault
	S	4 poles		
IT	SN	3 poles	Insulation resistance measurement	Triggered upon 2nd fault by overcurrent protection

3.5.3 TT system

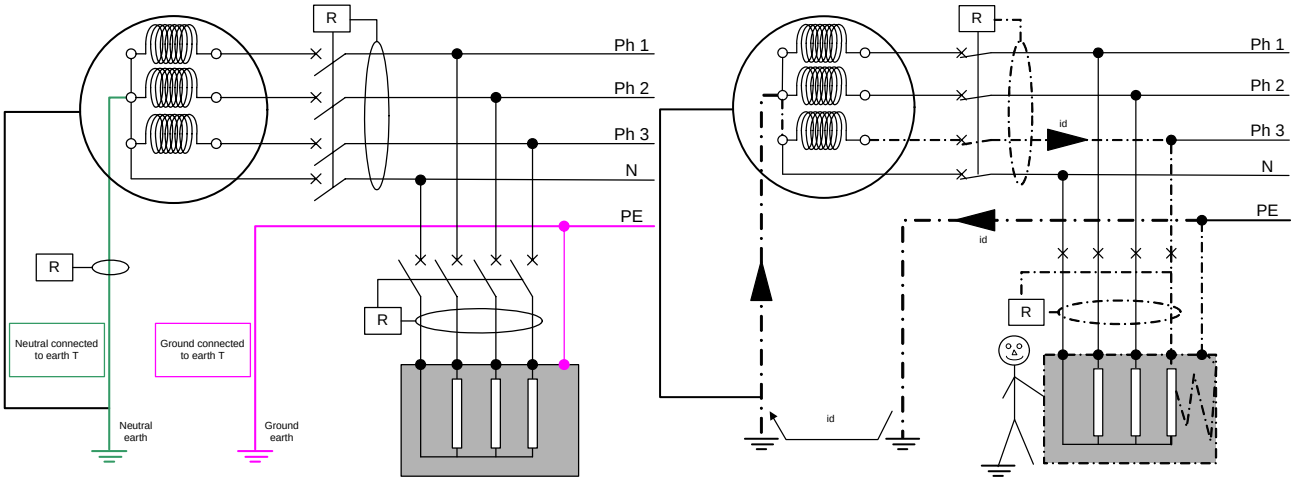


Figure 3.2: TT neutral system.

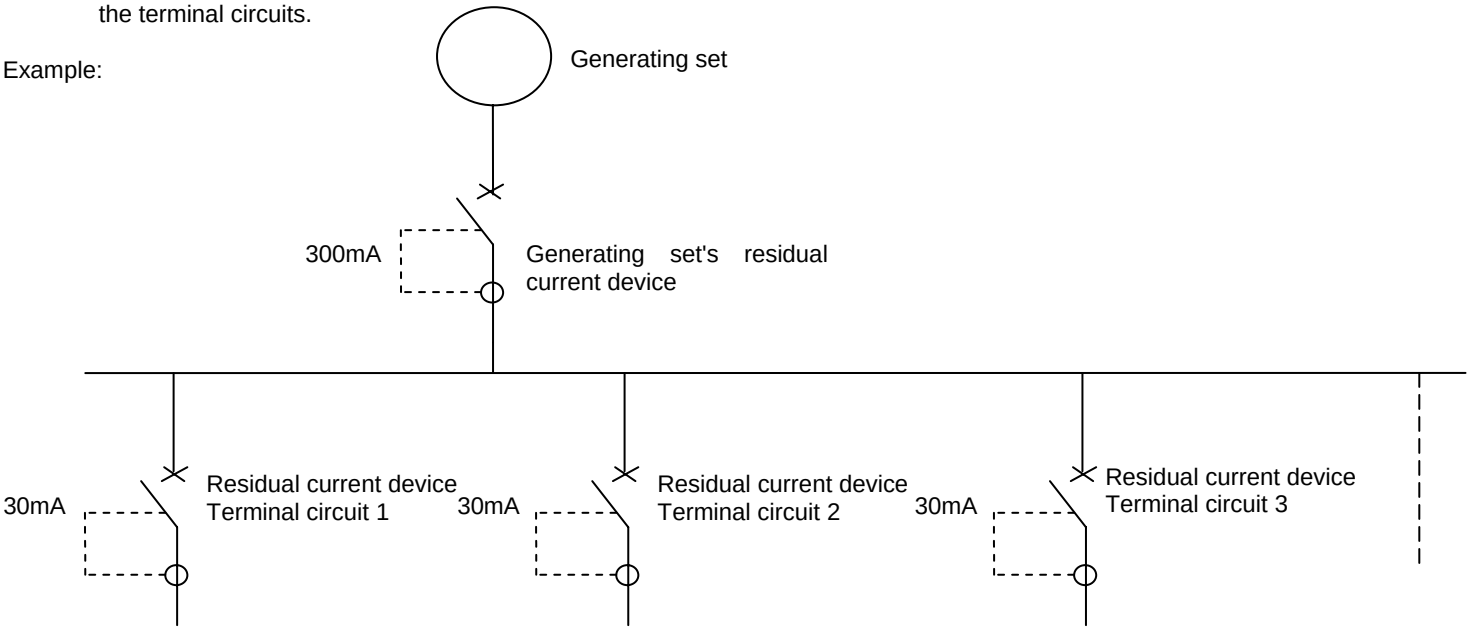
The alternator neutral is earthed, and the grounds of the user equipment have their own earth connection.
In the TT system, automatic power cut-off via a Residual Current Device (RCD) is obligatory at the upstream part of the facility, to ensure protection of personnel (with a maximum 30 mA device on outlet circuits).

3.5.4 Differential protection

In order to ensure that people are protected from electric shocks from the TT system, the generating set is equipped with a residual current device: this can be fixed or adjustable depending on the option chosen.

- If the generating set's residual current device is not adjustable and the activation threshold has been set at 30 mA, all terminal circuits in use are protected.
- If the generating set's residual current device is not adjustable and the activation threshold has been set at 300 mA, a 30mA residual current device must be added to each of the circuit outlets in use.
- If the generating set's residual current device is adjustable, (located upstream) this must be above those devices located downstream (terminal circuits); this means that continuity on clean circuits will be maintained in the event of a fault on one of the terminal circuits.

Example:

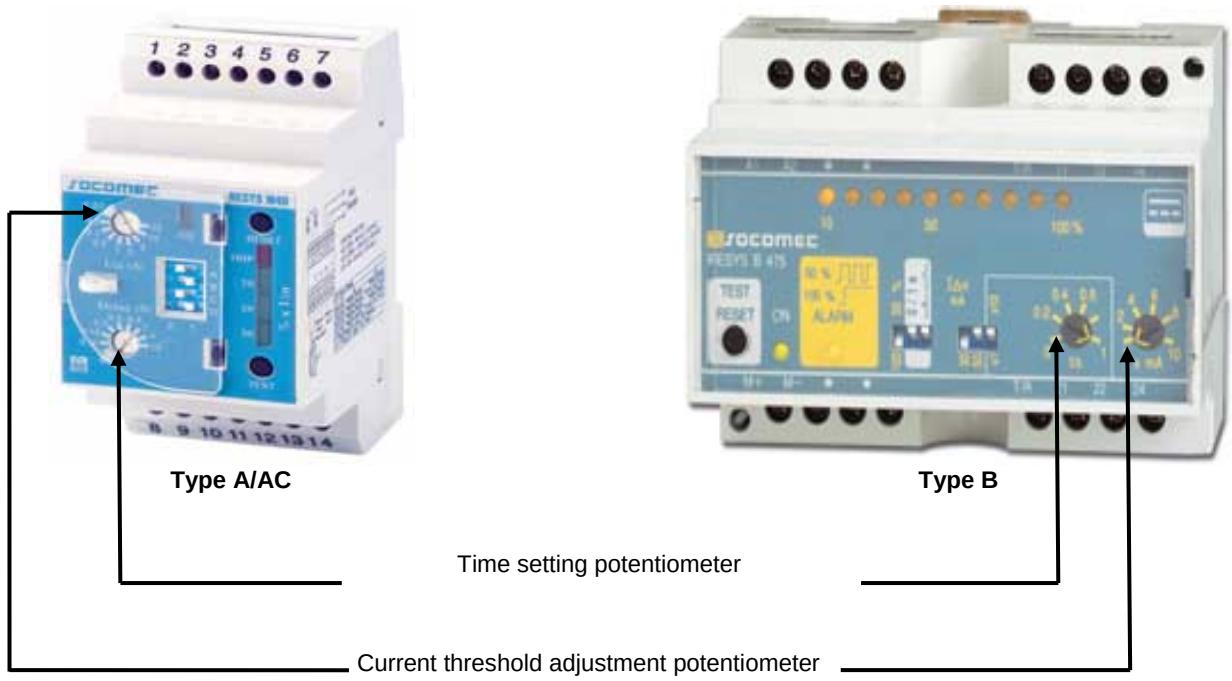


Important	**Any change to the setting on the generating set's residual current device could pose a risk to personal safety. The user will be held liable - any changes must only be made by trained, qualified engineers. When the generating set is disconnected from an installation after use, the general residual current device must be restored to factory settings by a qualified engineer who can then check this.**

3.5.5 Adjusting the genset differential protection

Before adjusting the settings on the generating set's residual current device, the following two parameters must be taken into account: the sensitivity of the current threshold and the activation time.

The generating set's residual current device must have, in relation to the downstream device (terminal circuit):
- a sensitivity three times greater.
- a longer cut-off time.



Two types of differential relay are fitted on the generating sets:

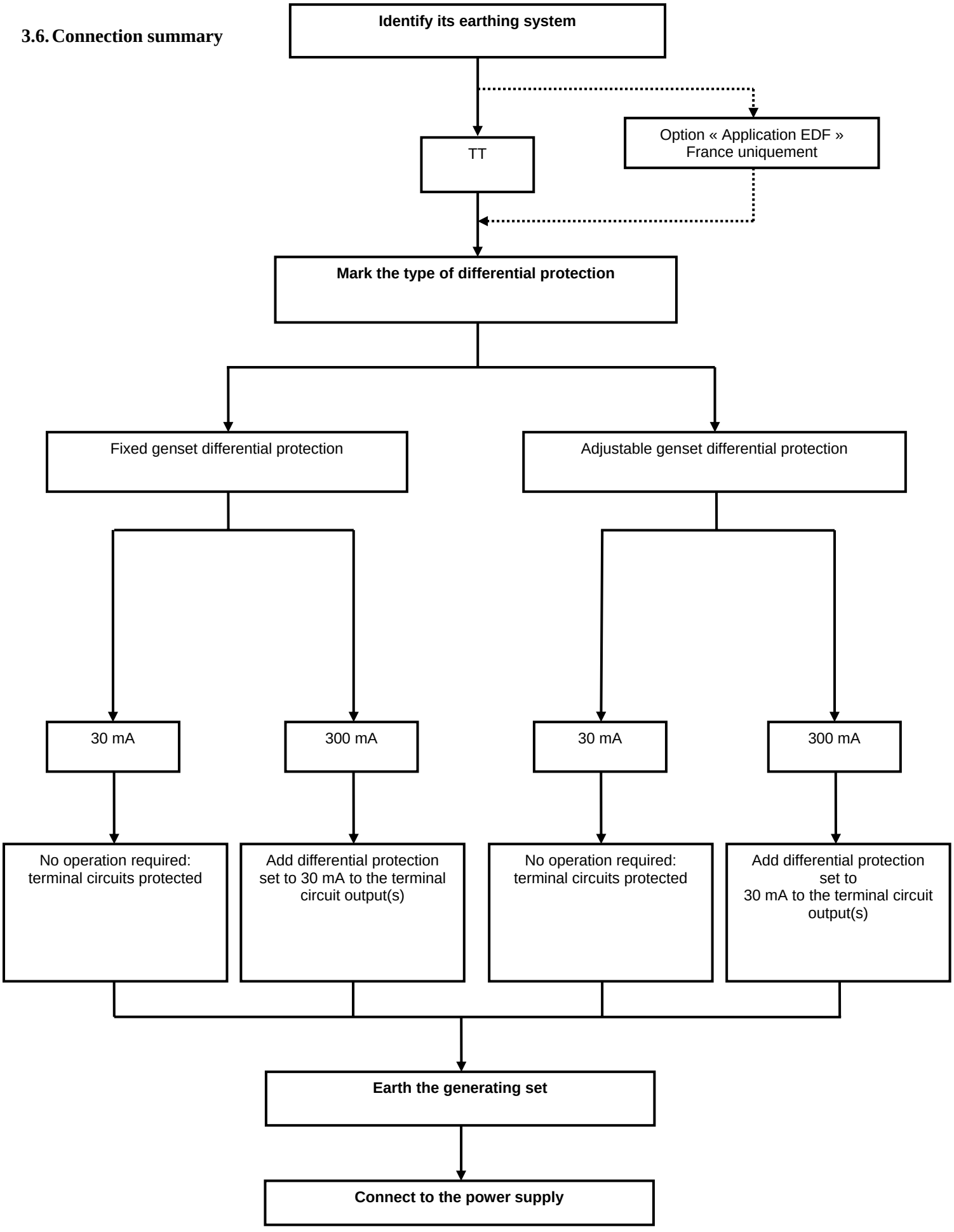
Type A:
Differential device for which operation is guaranteed:
- ✓ for residual sinusoidal alternating currents,
- ✓ for continuous pulsed residual currents,
- ✓ for continuous pulsed residual currents with a continuous component of 0.006 A with or without phase check, independent of the polarity.

Type B:
Device for which operation is guaranteed:
- ✓ as in the case of type A,
- ✓ for residual sinusoidal currents up to 1000 Hz,
- ✓ for residual sinusoidal currents superimposed on a pure continuous current,
- ✓ for continuous pulsed currents superimposed on a pure continuous current,
- ✓ for residual currents which could come from rectifier circuits i.e.:- three phase half-wave rectifier or a three-phase full-wave bridge rectifier, full-wave bridge rectifier between phases, with or without phase angle check, independent of the polarity.

Our residual current devices are factory-set with an activation threshold of 30 mA and with automatic cut-off. Depending on the use, if the residual current device is modified, it is recommended to fit a seal to prevent any tampering when the generating set is being used.

EN

3.6. Connection summary



3.7. Special arrangements

Generating sets are not fitted with protection against power surges caused by drops in atmospheric pressure or manoeuvring. The company does not accept any responsibility regarding damage caused by these occurrences.
However, lightning conductors can be installed, on the understanding that this does not give total protection.

4. Trailer

4.1. Trailer linkage

Before attaching the trailer, check the trailer hook on the tow vehicle; it should fit the trailer ring perfectly.

Warning	**Trying to tow a trailer with a non-matching device (bar, wires, cords, etc.) could lead to serious accidents.** **Also check:** **- no incipient fractures or excessive wear on the hitching system.** **- locking system is operating properly.**

To hitch the trailer, proceed as follows:

❶ Lock the wheels to stop the trailer from moving
❷ Lift up the rear trailer supports and lock them
❸ Release the parking brake
❹ Release the locking levers for the draw bar arms and adjust the ring to the same height as the vehicle hook
❺ Hitch the trailer, remove the locks on each side of the wheels then lift up the front wheel fully using its handle
❻ Connect the electrical circuit of the trailer to that of the tow vehicle
❼ Hook the handbrake safety wire onto the hook on the tow vehicle.

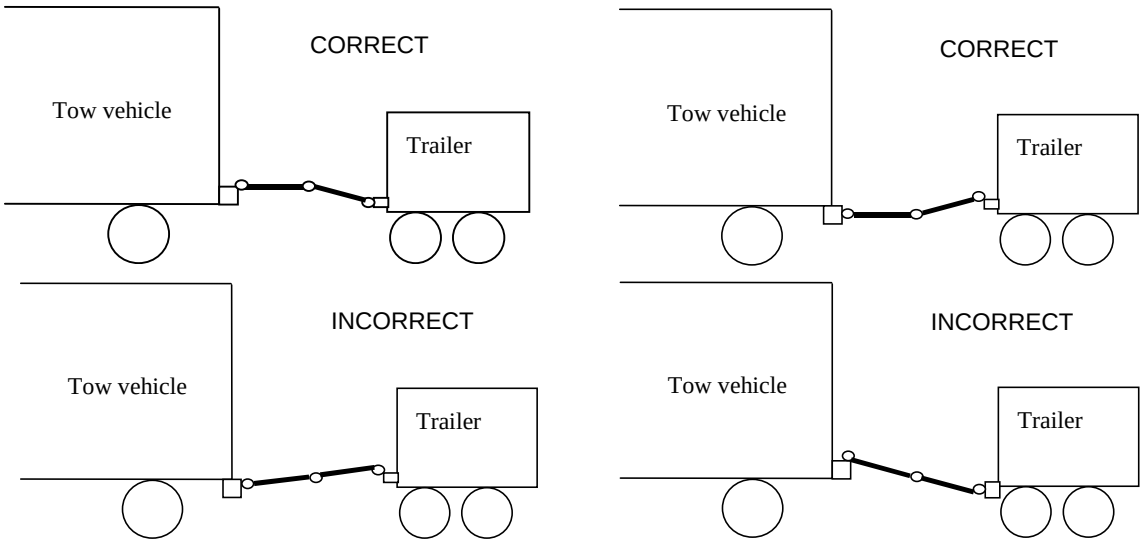


Diagram 4.1 : Coupling a trailer

4.2. Check before towing

Before towing, check the following:
- ✓ Tightness of the generating set enclosure bolts.
- ✓ Wheel tightness.
- ✓ Hitching hook locked.
- ✓ Tyre pressure.
- ✓ Signalling lights working, for "on-road" trailers.
- ✓ Enclosure doors closed.
- ✓ Parking brake released, for "on-road" trailers.
- ✓ Guide wheels (jockey wheels) and stands lifted (if fitted).
- ✓ Towbar arm locking levers tightened and pinned (if fitted with an adjustable towbar).
- ✓ Brake test, for "on-road" trailers.
- ✓ Safety cable fitted, for "on-road" trailers.

4.3. Operation

"On-site" trailer

These trailers are not fitted with a main brake, and so cannot be braked in motion; the tyres allow for a maximum speed of 27 km/h. So it is absolutely prohibited to exceed this speed.

Nor are these trailers fitted with signalling lights. On-road use is prohibited.

"On-road" trailer

The driving speed must be suited to the condition of the road and the handling of the trailer.

Driving at high speed causes heating of the tyres; so it is important to stop from time to time, and check them. Excessive heating may cause a puncture, and therefore a serious accident. For reversing manoeuvres, remember to lock the inertia brake.

Warning	Particular attention must be paid to the tightness of the wheels on new vehicles. In the first few miles' driving, heating of the brake hubs and drums will actually reduce the wheel tightness. It is therefore essential to check the tightness every 6 miles (10 kilometres) until no further loosening is noted. Nonetheless the tightness must be checked whenever you are about to tow the trailer.

Lights/signalling (only for "on-road" trailers)

Warning lights are obligatory for on-road driving. Signalling must comply with regulations in force in the country of use.

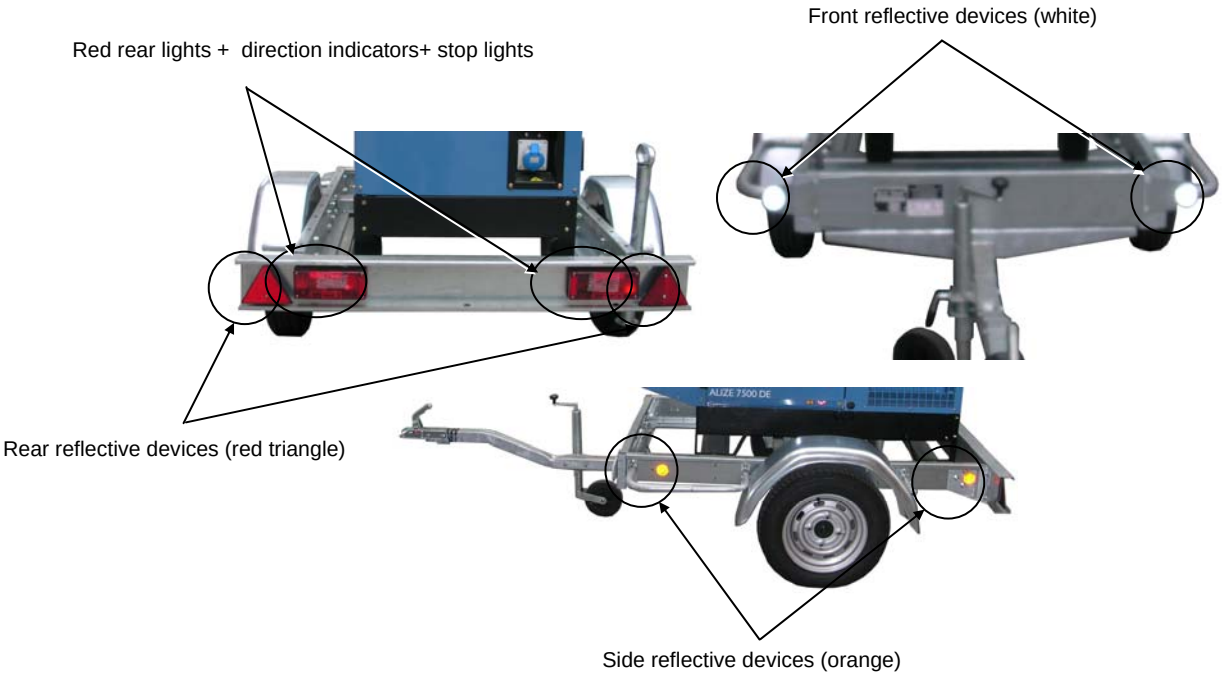

Front reflective devices (white)
Red rear lights + direction indicators+ stop lights
Rear reflective devices (red triangle)
Side reflective devices (orange)

Figure 4.2: Example of French signalling

4.4. Unhitching the trailer

This operation should be carried out on horizontal, flat, stable ground.

1. Lock the wheels
2. Lower the front wheel
3. Disconnect the road signals wire
4. Refit the hitch using the wheel to release the hook ring from the tow vehicle,
5. Release the tow vehicle
6. Engage the handbrake.

4.5. Implementation for installation

Operations to be carried out:

- ✓ Ensure that the ground is strong enough for the assembly not to sink into it.
- ✓ Unhitch the trailer.
- ✓ Immobilise the trailer by placing chocks under the wheels.
- ✓ Fully engage the parking brake (if fitted).
- ✓ Using the front wheel, position the generating set as close to horizontal as possible.
- ✓ Lower the stands (if fitted), and lock them.

4.6. Break transmission adjustment

⚠ Important	- The handbrake is used only as a parking brake. - Setting is carried out starting with the brakes moving to the brake control.

❶ After fitting the wheels on the axle, turn the wheels in the FORWARD direction (on all RA 2 type brakes, check that the adjustment screw 8 reaches the “FORWARD” stop on the brake backing plate).

❷ Adjust the brake setting using screw 8, with the cables not connected to the cross bar(s). The shoes should rub the drum slightly.

❸ Connect the brake cables to the cross bars(s) and tighten the nuts and lock nuts, leaving the end of the threaded end protruding by around 10 mm (Fig. 4.4).

IMPORTANT: Wherever possible, cables must cross over to achieve the highest possible gain curve (Fig. 4.5).

❹ Check that the parking lever 1 is in the ‘REST” position and that the compensating spring 4 is completely free on its rod (unscrew the nuts 5 fully).

❺ Check that the hook slide 2 is not compressed and the yoke 3 is in the pulled out position.

❻ Fit the transmission and adjust the assembly using the tensioner 6 until a gap (J1) of 1 mm max is obtained between the linkage 9 and slide 2.

❼ Adjust the compensating spring 4 at one end pressing it against the anchorage plate, and at the other end leaving a 2 mm gap (J2) max between the spring and nuts 5.

❽ Tighten all the lock nuts.

Checking the setting (trailer on axle stands):

❶ Pull the parking lever 2 notches - the wheels cannot turn in a FORWARD direction.
The wheels can turn in REVERSE (adjustment screw 8 switches to the REAR position).

❷ Pull the parking lever fully.
The wheels will not turn either in FORWARD or REVERSE and the cross bar(s) must remain parallel with the axle body.

- ➢ Check the transmission setting after 180 miles (300 km) (running in period) and if necessary adjust the gap (J1) using the tensioner.

Parking

- ➢ The lever must be fully pulled up, so that the compensating spring is fully compressed.
- ➢ Every 900 miles (1500 km), check the braking settings and distribution on all the wheels.

Important

- ➢ The brake controls are designed to draw trailers behind flexible suspension touring vehicles. If used behind an HGV, be sure to provide the fitted ball joint with a shock absorber to prevent premature wear.
- ➢ During any manoeuvres with the trailer coupled, do not turn more than 90° or force reverse.

- ➢ The specifications of our brake controls are indicated on a manufacturer's plate, and the items on this should be supplied to us when requesting replacement parts, in particular for the shock absorber, of a special type, approved by the Service des Mines to correspond to European standards (it is advisable to have a spare shock absorber to enable instant repairs).

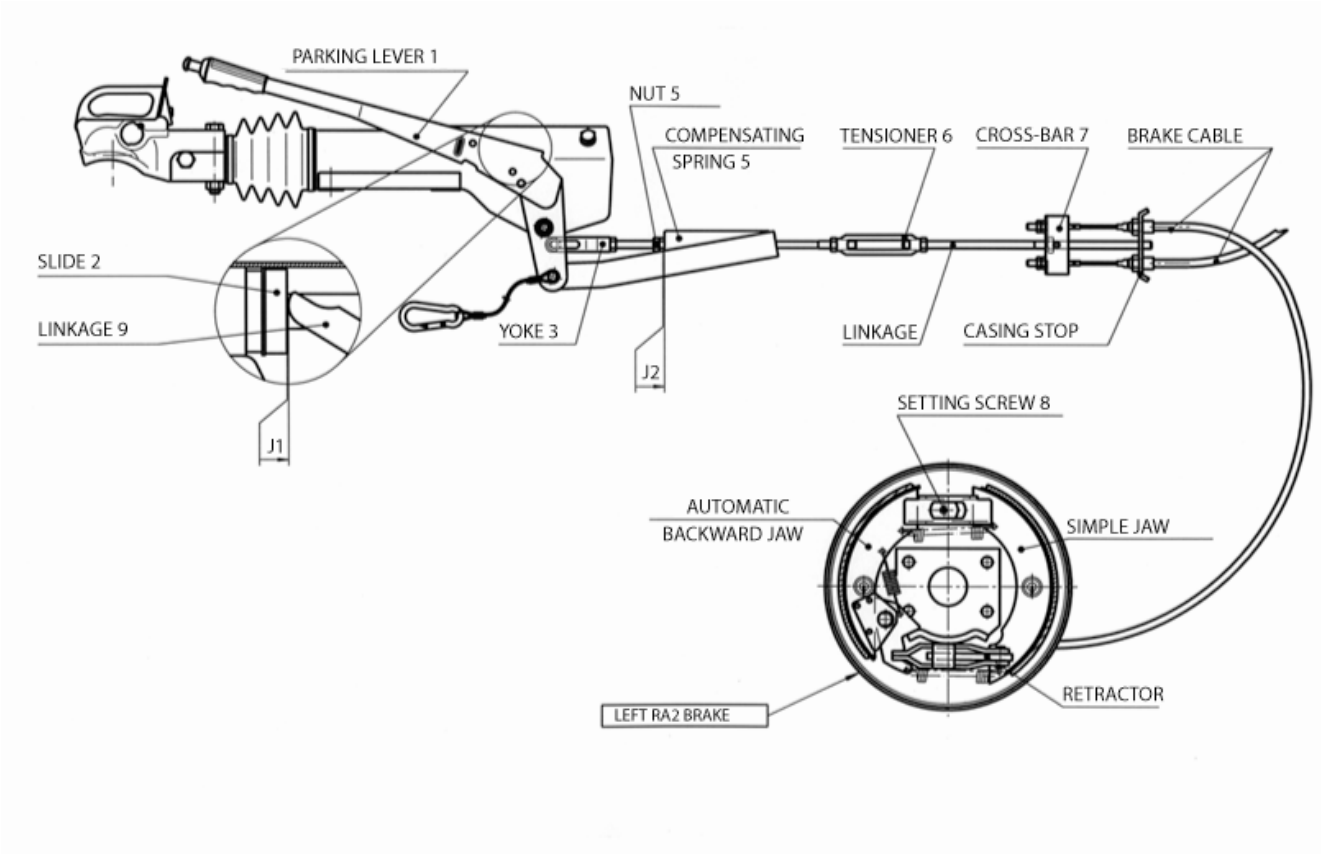


Figure 4.3: Braking transmission

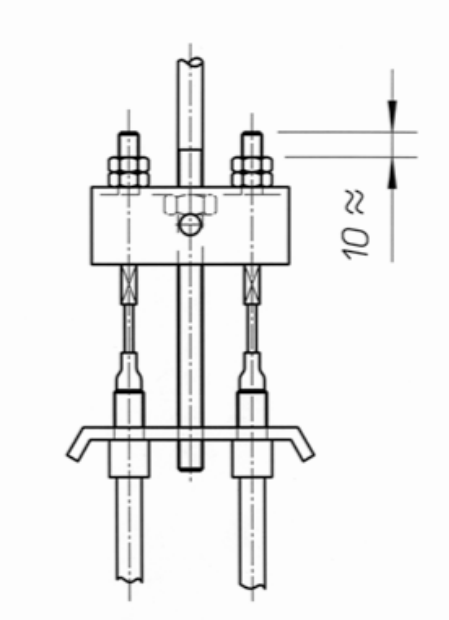


Figure 4.4: Cross bar fitting

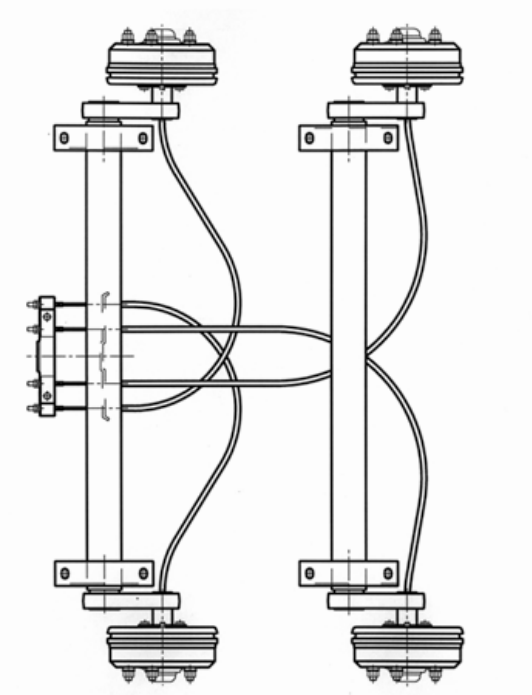


Figure 4.5: Tandem bearing fitting

4.7. Faults and repairs

Fault observed	Origin	Solutions
Erratic braking of trailer	- Faulty shock absorber	Replace the shock absorber
Braking too weak	- Jaws worn	Replace the jaws
	- Jaws not run in	Fault will disappear only after running in
	- Incorrect linkage setting	Adjust the setting
	- Significant friction on the slide	Grease the sliding parts
	- Slide corrosion	Remove the corrosion and grease
	- Coupling height does not match that of the towing vehicle	Adjust the height so that the two parts are in the same horizontal plane
Drum temperature abnormally high	- Incorrect linkage setting	Adjust the settings
	- Incorrect brake setting	Adjust the settings
	- High levels of dust in the drums	Remove the dust
	- Jaws, springs, drums damaged	Replace the damaged parts
	- Brake cables or link rod damaged	Replace the damaged parts
Jerky braking	- Incorrect linkage setting	Adjust the settings
	- Interfering parts on the slide	Remove, clean and grease
	- Corroded slide	Remove the corrosion and grease
	- Damage to slide guide rings	Replace the rings (and possibly the slide) and grease
	- Faulty shock absorber	Replace the shock absorber
Trailer tending to swerve upon braking	- Cross-bar(s) not balanced	Adjust the cross-bar(s)
	- Different brake setting on the two sides	Adjust the brake settings
	- Cables damaged or incorrectly fitted	Replace the damaged parts Refit the cables
	- Poor load distribution	Check the load distribution
When starting the trailer holds back the towing vehicle	- Damage to slide or to guide rings	Replace the faulty parts and grease
	- Slide corrosion	Remove the corrosion and grease
	- Tie rod damaged	Replace the tie rod and adjust the settings
	- Linkage damaged or incorrectly set	Replace the damaged parts and adjust the settings
	- Brake on	Loosen the brake
Play in the coupling head	- Head worn (see wear indicator)	Replace the head
	- Ball joint worn	Replace the ball joint
Parking braking too weak	- Compensating spring incorrectly set	Adjust the setting
	- Braking system incorrectly set	Adjust the setting
	- Notched sector damaged	Replace the sector and adjust the setting
	- Lever ratchet worn	Replace the lever and adjust the setting
	- Cable ruptured	Replace the cable and adjust the setting

4.8. Electrical connection diagram

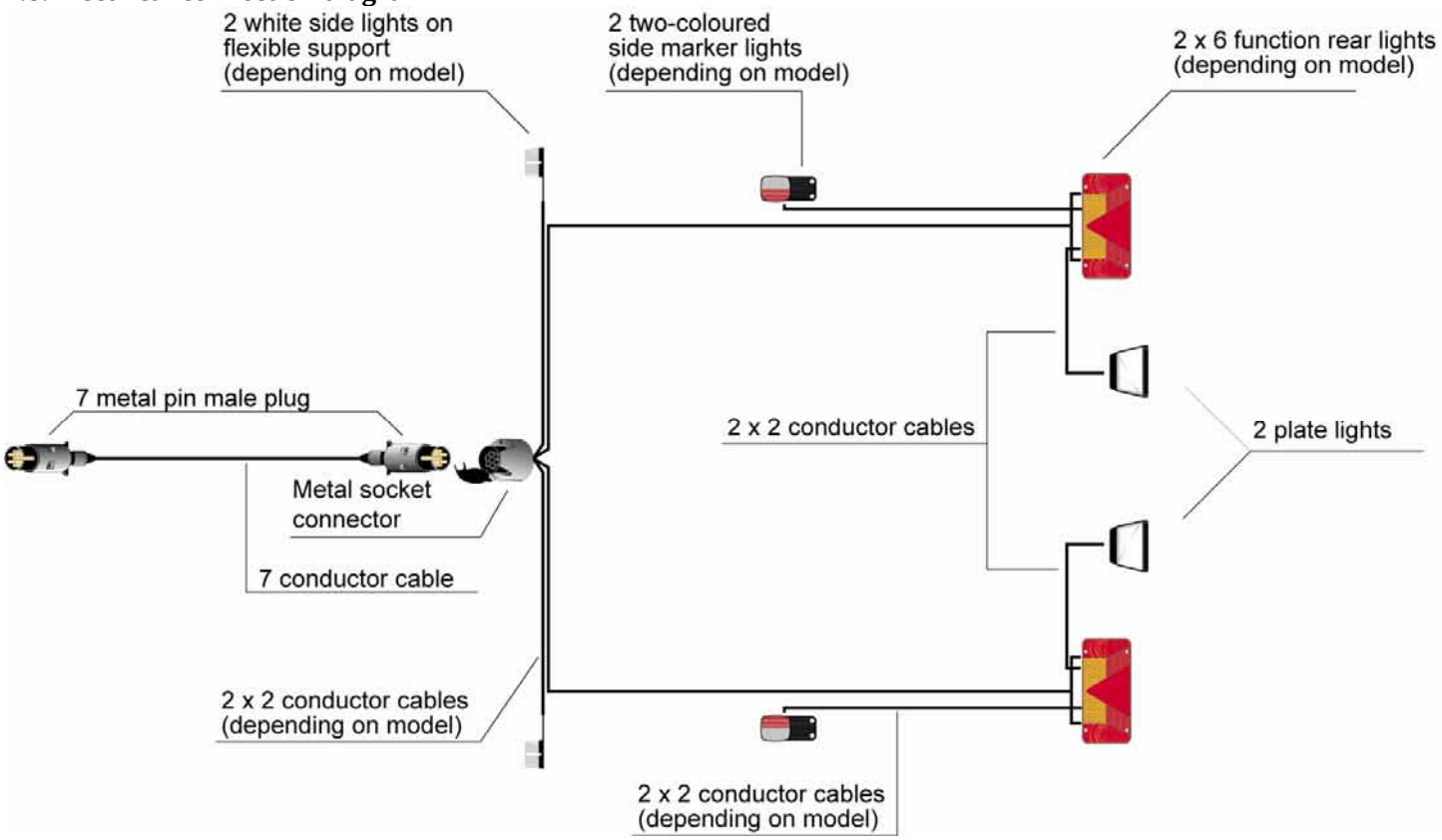

2 white side lights on flexible support (depending on model)
2 two-coloured side marker lights (depending on model)
2 x 6 function rear lights (depending on model)
7 metal pin male plug
Metal socket connector
7 conductor cable
2 x 2 conductor cables
2 plate lights
2 x 2 conductor cables (depending on model)
2 x 2 conductor cables (depending on model)

Figure 4.6 : Electrical connection diagram

4.9. Complete wheels technical information

TYRES					**COMPLETE WHEELS**	
Dimensions	Indices	Diameter (mm)	Cross section (mm)	Radius under load (mm)	Load (Kg)	Pressure (bar)
135 R 13	[illegible]	550	134	265	335	2.4
145 R 13	75 T	566	145	272	387	2.4
155 R 13	79 T	578	150	277	437	2.4
145/70 R 13	71 T	534	150	259	345	2.5
155/70 R 13	75 T	548	147	263	387	2.5
185/70 R 13	86 T	594	185	285	530	2.5
165 R 14 C	98 N	622	172	284	650	3.8
155/70 R12	100 N	525	155	244	650 (1) 800 (2)	6.25
185 R 14 C	102 P	650	188	316	675 (1) 850 (2)	4.5
195 R 14 C	106 P	666	198	32	950	4.5
195/50 x 10	98 N	450	190	-	750	6.0

(1) Wheel with 4 holes (2) Wheel with 5 holes

5. Preparation before operating the set

	The inspections referred to in this section enable the electrical generator set to operate. Specific skills are required to carry out these operations. They must only be entrusted to personnel with the necessary skills. Failure to follow these instructions in any way could result in malfunction or very serious accidents.
Danger	

5.1. Installation checks

- Check that the general recommendations from section "Installation" (ventilation, exhaust, connections, etc.) are followed.
- Carry out level checks (oil, coolant, diesel, battery).
- Ensure that the generating set is correctly earthed (earthing rod).
- Ensure that the electrical connections have been made properly.
- Ensure that the fuel connection has been made properly (valve position), if the generating set is equipped with the three-way valve option enabling external supply.

5.2. Checks after starting the generating set

- Carry out the mechanical checks (oil pressure, water temperature, absence of noise, etc.).
- Carry out the electrical checks (voltage, current, frequency, rotary field, etc.).
- Carry out the safety checks (emergency shutdown, oil pressure, coolant temperature, etc.).
- Carry out the check on Normal/Emergency Inverter switching or coupling (if fitted).

6. Using the generator set

6.1. Pre-Start Inspection

- Inspecting the engine compartment

- Make sure there is no combustible material near the engine or battery. Also, check to make sure that the engine and battery are clean. If combustible materials or dust are found near the engine or battery, remove them.
- Check the electrical wiring for such components as the starter and alternator for looseness
- Check the entire engine for fuel leakage, engine oil or coolant. If leakages are found, repair.
- Make sure the following valves, plugs and cocks are open or closed (tightened) properly:
  - ✓ Fuel feed valve: Open
  - ✓ Coolant drain cock (plug): Closed (Tightened)
  - ✓ Oil drain valve: Closed

- Checking the engine oil level

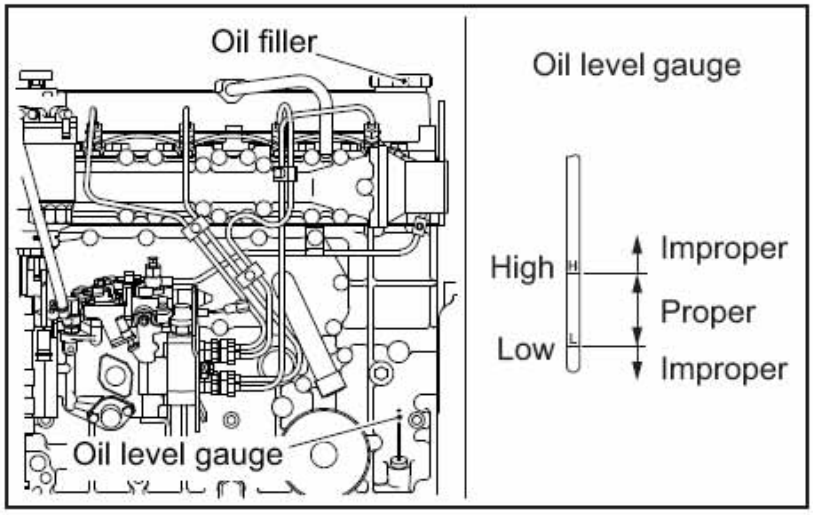
⚠ Important	- Do not top up the oil if the oil level is not below the low level marker.

❶ Pull out the oil level gauge and wipe it clean using a waste cloth.

❷ Insert the oil level gauge fully into the oil level gauge guide, then pull out the gauge again.

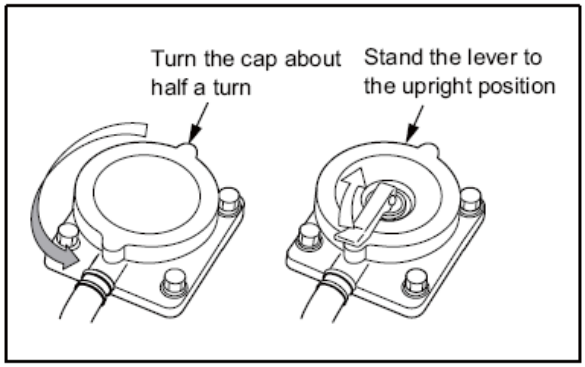
❸ The proper oil level is between the high and low marks on the oil level gauge. If the oil level is low, add engine oil of the specified type.4. Install the oil filler cap after refilling.

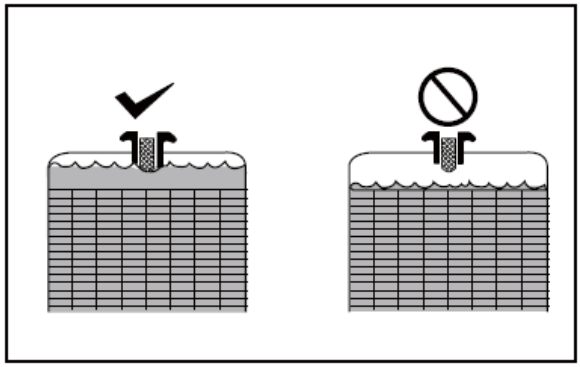
❹ Check the oil pan and other area for oil leakage.



- **Checking the coolant level**

Warning	Remove the radiator filler cap only after the engine has cooled to room temperature. Place a waste cloth over the cap, and loosen the cap about a half-turn or stand the lever to the upright position to release internal pressure. Never open the radiator filler cap while the engine is hot, otherwise the steam or hot coolant spurts out and you may be scald with it.





❶ Open the radiator filler cap and check the coolant level.
❷ If the coolant level is low, add coolant to the speci-fied level.
❸ Check for leaks in the cooling circuit.

- **Checking the air filter**

Important	A clogged filter element limits the engine's air intake and a reduced air supply to the engine.

If the air filter is fitted with a dust control valve (A), press the tip of the valve to evacuate any accumulated dust particles.

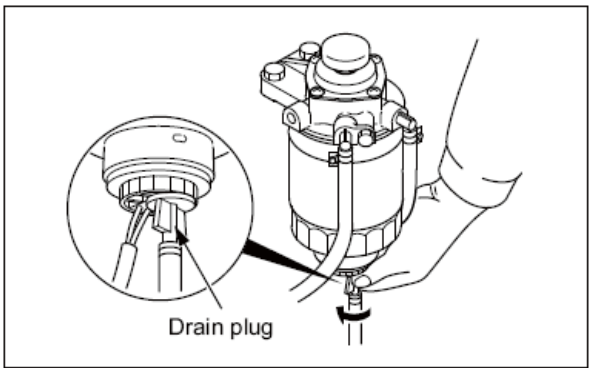
Check the air filter clogging indicator (B). If the indicator is red, clean the air filter.

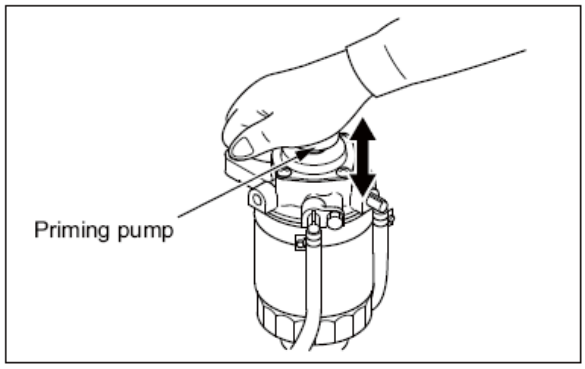
- **Checking the fuel filters**

Danger	**When handling fuel, make sure there are no open flames or other fire hazards near the engine. Wipe off any spilled fuel completely.Spilled fuel can ignite and cause a fire.**

Drain water for the fuel filter if the warning of water draining for fuel filter is occurred.

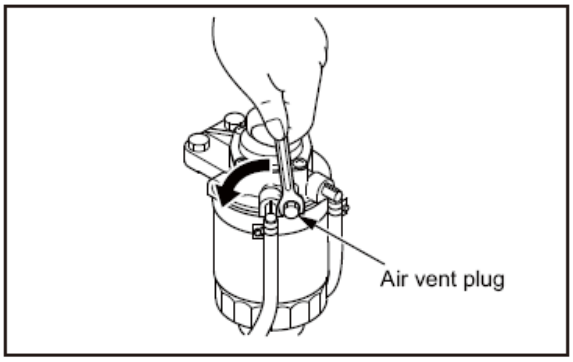
❶ Place a drip tray under the drain hose.
❷ Loosen the drain plug and drain water from the fuel filter.
❸ Feed fuel by pushing down on the priming pump (about seven strokes) to facilitate draining.
❹ After draining, tighten the drain plug securely.
❺ After drain the fuel filter, bleed the fuel system.For bleeding air from fuel system.

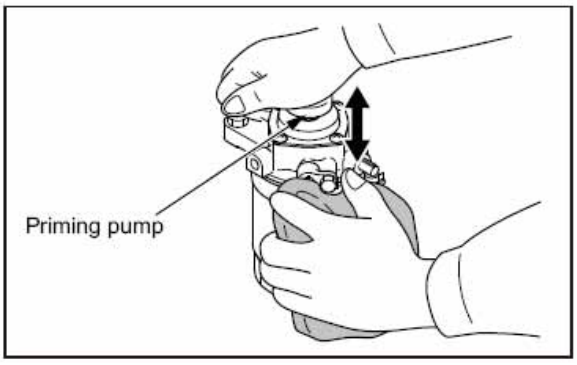




For bleeding air from fuel system:

❶ Loosen the air vent plug on the fuel filter about 1.5 turns.
❷ Apply a cloth to the air vent plug.
❸ Repeat pumping until the fuel flow from air vent plug becomes free of bubbles.
❹ Tighten the air vent plug and clean.





6.2. Generator set with NEXYS control panel

6.2.1 Control panel presentation

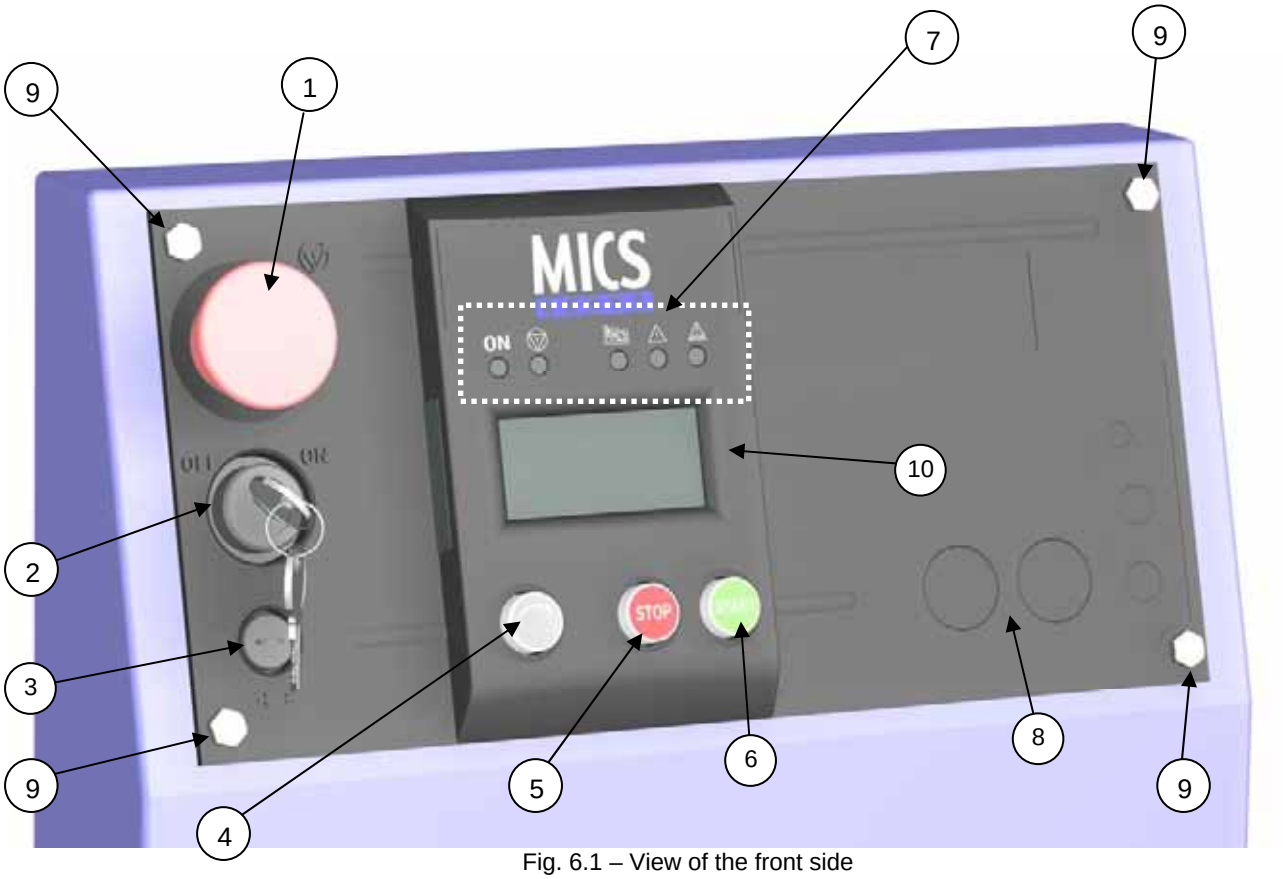


Fig. 6.1 – View of the front side

① Emergency stop button for switching off the generating set in the event of a fault which could endanger personnel or damage equipment
② Key switch for starting up/shutting down the module and RESET function
③ Electronic card protection fuse
④ Screen-scroll button, press successively to access the various screens which are available
⑤ STOP button, press to switch off the generating set
⑥ START button, press to switch on the generating set
⑦ Normal operation LEDs and alarm and fault warning LEDs
⑧ Slot reserved for panel fascia options
⑨ Mounting bolt.
⑩ LCD for displaying alarms and faults, operating states, electrical and mechanical quantities

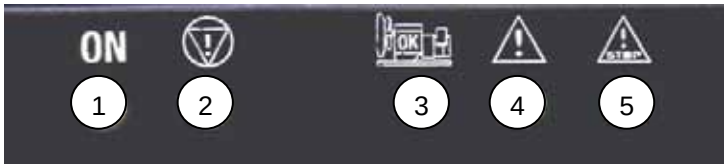


Fig. 6.2 – Description of the LEDs

A lit LED indicates:

① Module being supplied (green, lights up and remains lit)
② Emergency stop activated (control panel or external emergency stop) (red, lights up and remains lit)
③ Visualisation of starting phase and speed/voltage stabilisation (flashing) and generating set operating OK or set ready to generate (green, lights up and remains lit)
④ General alarm (orange, flashing)
⑤ General fault (red, flashing).

6.2.1.1. Introduction to pictograms

The pictograms are as follows:

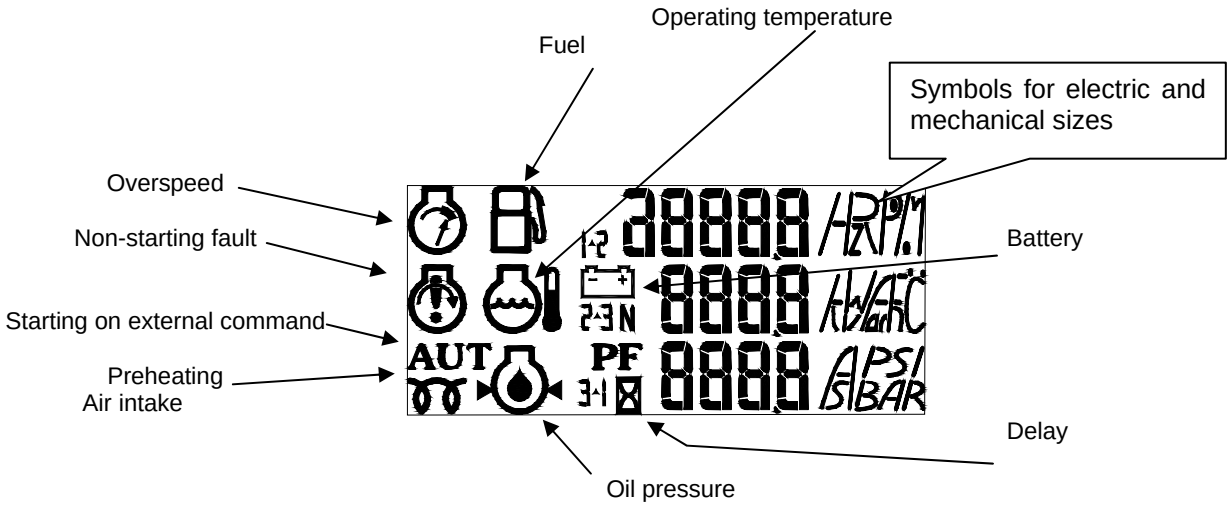


Fig. 6.3 – View of pictograms

- The "fuel level" pictogram is used to display the fault, the alarm and the fuel level.
- The "operating temperature" and "oil pressure" pictograms are used to display the fault and analog value
- The "overspeed" and "non-starting fault" pictograms are used to display the fault.
- The "battery" pictogram is used to display the "alternator charge" fault and to indicate the battery voltage.

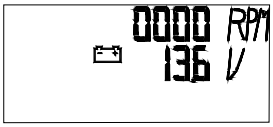
6.2.2 Manual starting

⚠ Danger	Check that the generating set circuit breaker has triggered.

❶ connect the generating set battery.

❷ turn the key switch to the ON position (without forcing it)

- ✓ All of the LEDs light up for 2 seconds, to confirm that they are operating correctly.
- ✓ If the LEDs do not light up, check the protection fuse and replace it if necessary.
- ✓ All the items on the screen are displayed for 2 seconds.
- ✓ Only the "ON" LED remains lit to indicate that the module is powered up.
- ✓ The following screen appears.

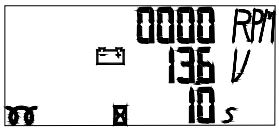


The first line displays the motor speed in RPM.
The second line displays the battery voltage in volts (V).

- ✓ Check the battery voltage (min. 12 V)

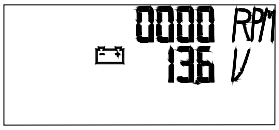
❸ Press (once briefly) the green "START" button.

- ✓ If the motor is equipped with an air preheating system, there is a 10-second delay before the motor starts (preheating activation period).
- ✓ The following screen appears



The third line displays the air preheating time remaining (with pictograms representing a resistor and an hourglass).

- ✓ If the motor is not fitted with an air preheating system or once the preheating delay has elapsed, the engine starts up (start of a cycle comprising 3 attempts to start up the engine).
- ✓ The following screen appears.



⚠ Warning	The number of successive and automatic starting attempts is limited to 3.

Note: the LED flashes as soon as the START button is pressed and continues to flash until the frequency stabilises if a "measurements" card has not been inserted and until the frequency and voltage stabilise if a "measurements" card has been inserted.

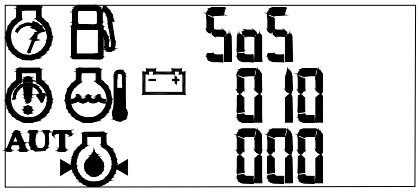
Following stabilisation, the LED light comes on continuously.

6.2.3 Switching off

❶ trigger the circuit breaker located at the base of the centre console
❷ Let the motor run under no load for 1 to 2 minutes to allow it to cool.
❸ press the "STOP" button to stop the generating set.
❹ switch off the MICS Nexys module by switching the key to "OFF" (without forcing it).

6.2.4 Alarms and faults

The appearance of a fault or an alarm causes the following screen to be displayed (one or more pictograms or a fault code along with the SOS message are displayed).

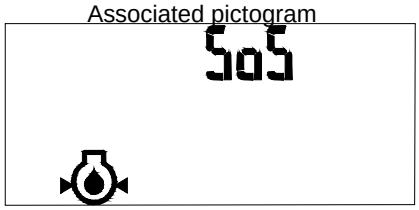
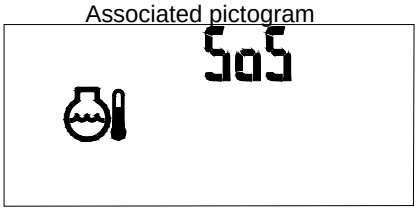
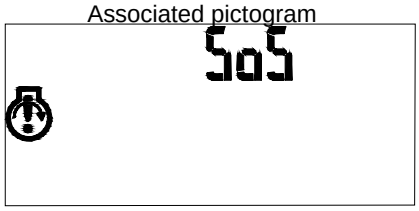


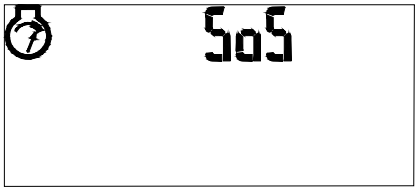
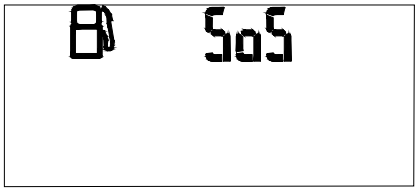
The user can access the following screens by pressing the key

The fault or alarm screen will disappear once the fault or alarm has been removed.
Only one fault is displayed on this screen (the fault which caused the generating set to stop).
If one or more faults have appeared after the first fault, they can only be displayed after the first fault has been reset (press "Reset" as many times as the number of faults present).
Note: an alarm can appear at the same time as a fault.

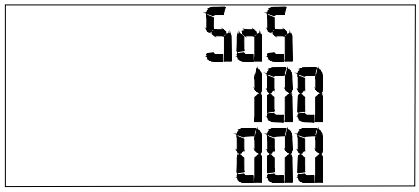
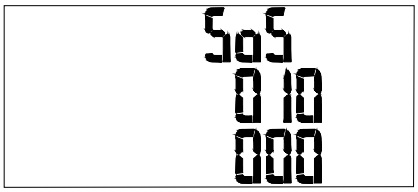
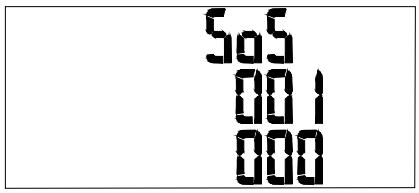
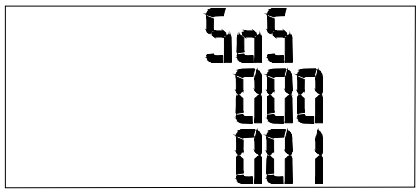
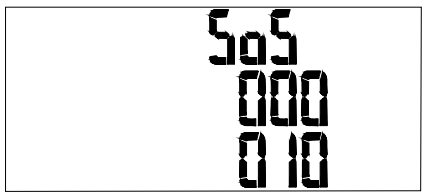
6.2.5 Faults and alarms - Details

List of faults which will cause the generating set to stop and generate a pictogram

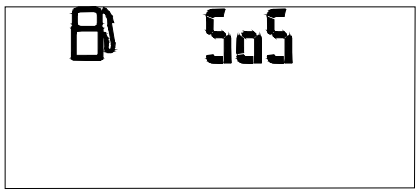
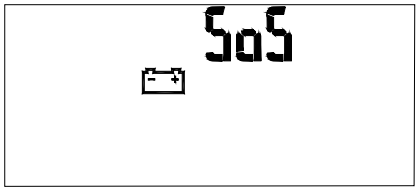
Oil pressure fault: Indicates that the oil pressure is incorrect	Associated pictogram 
Engine temperature fault: Indicates that the engine temperature is too high.	Associated pictogram 
Non-starting fault: Indicates that there have been three consecutive unsuccessful starting attempts.	Associated pictogram 

Overspeed fault: Indicates an excessive generating set running speed.	Associated pictogram 
Low fuel level fault: Indicates the need to top up the fuel.	Associated pictogram 

List of faults which will cause the generating set to stop and generate a fault code

Low coolant level fault: indicates that the level of coolant is low in the radiator (linked to a two second time delay). Or Overload or short-circuit fault (optional): with the circuit breaker SD contact closing (overload or short-circuit), the generating set switches off immediately also causing the main circuit breaker to be triggered.	Associated message 
Additional fault linked to message opposite: is displayed in the following two cases: ➢ Differential fault (1) ➢ insulation fault (2) (1) Differential fault (optional): with a differential fault causing the activation of the differential relay, the generating set stops immediately also causing the main circuit breaker to be tripped. (2) Insulation fault (optional): with an insulation fault causing the activation of the control unit performing insulation, the generating set stops immediately.	Associated message 
Underspeed fault: indicates an incorrect rotation speed (below 1000 rpm).	Associated message 
Emergency stop or external emergency stop fault	Associated message 
"STOP" fault activated if the "STOP" button is pressed whilst the "AUT" LED is flashing to indicate that the generating set is operating in automatic mode.	Associated message 

List of alarms associated with a pictogram

Low fuel level alarm: Indicates the need to fill up with fuel.	Associated pictogram 
"Alternator charging fault" alarm indicates a problem affecting the alternator charging rate.	Associated pictogram 

6.3. Generator set with TELYS control panel

6.3.1 Control panel presentation

6.3.1.1. View of the front panel

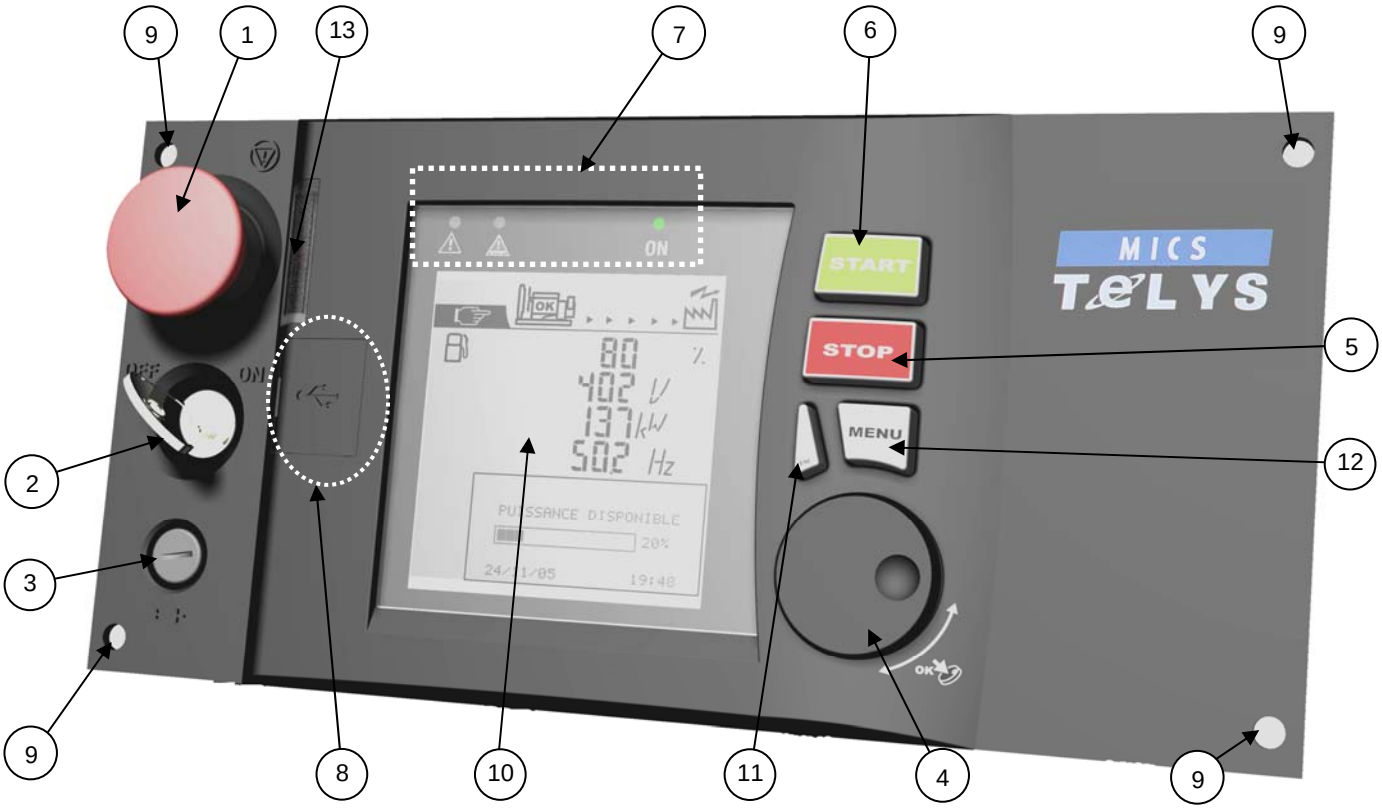


Fig. 6.4 - View of the front panel

1 Emergency stop button (AU) for switching off the generating set in the event of a fault which could endanger personnel or damage equipment.
2 Key switch for switching the module on/off.
3 Electronic board protection fuse.
4 Scrolling and selection wheel for scrolling through the menus and screens and selecting items simply by pressing the wheel.
5 STOP button, press to switch off the generating set.
6 START button, press to switch on the generating set.
7 Power ON LEDs and alarm/fault warning LEDs.
8 Location of USB ports.
9 Mounting bolt.
10 LCD for displaying alarms and faults, operating statuses, electrical and mechanical quantities.
11 ESC button: for returning to the previous selection and for default RESET function.
12 MENU button for accessing the menus.
13 Lighting for the emergency stop button.

Fig. 6.5 – Description of the LEDs

A lit LED indicates:
1 Alarm activated (flashing yellow).
2 Fault found (flashing red).
3 Module on (green, on continuously).

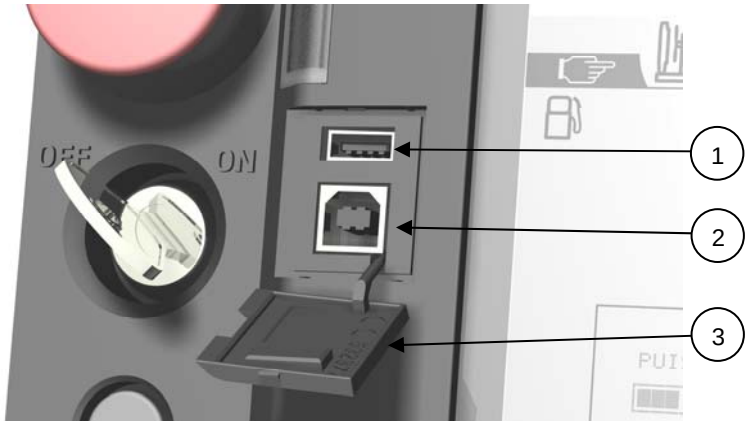


Fig. 6.6 – Close-up of USB ports

1 USB key connection (HOST): file transfer between USB key and TELYS and vice versa.
2 Connection for microcomputer (DEVICE):
- file transfer between PC and TELYS and vice versa,
- main module power supply.

3 Protective cover.

6.3.1.2. Description of the screen

The screen is backlit and requires no contrast adjustments. This screen is divided into 4 zones.

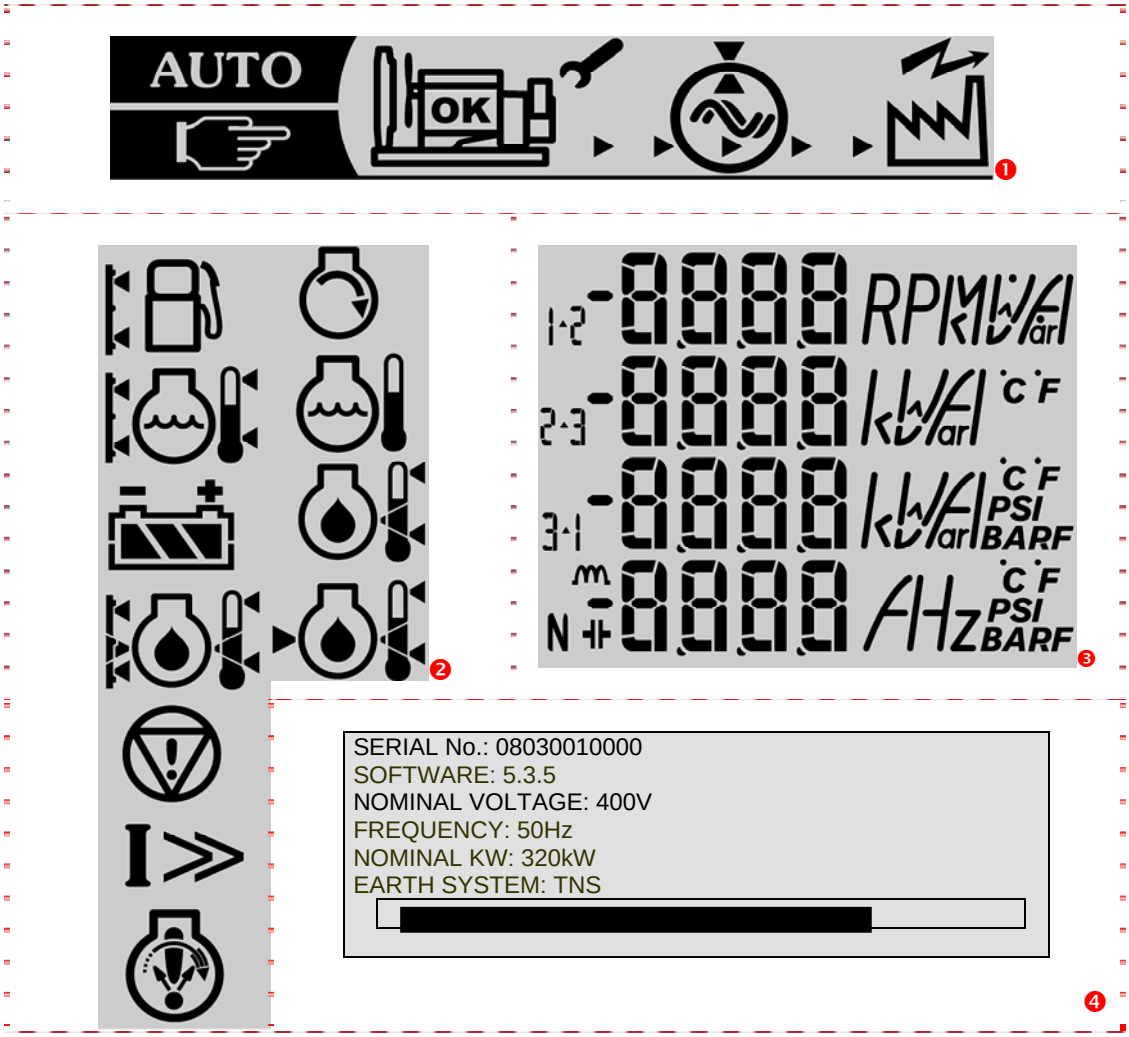


Fig. 6.7 – description of the screen (example)

❶ Zone 1: in this zone, the status of the generating set is displayed
❷ Zone 2: in this zone, pictograms relating to dimensions measured are displayed, as well as Alarm and Fault pictograms
❸ Zone 3: in this zone, the measured values corresponding to the measured dimensions are displayed with the corresponding units of measurement
❹ Zone 4: in this zone, messages relating to the control of the generating set and the menus are displayed.

Note: the information displayed on measurements, alarms and faults as well as messages and menus relating to control of the generating set will depend on the equipment level of each generating set. Certain screens may therefore not be present.

6.3.1.3. Description of the pictograms in zone 1

Pictograms in zone 1

Pictograms	Display	Activation conditions
"MANU" Mode	Fixed	TELYS in manual mode (MANU)
	Flashing	For 5 seconds when switching from AUTO mode to MANU mode
"AUTO" Mode	Fixed	TELYS in automatic mode (AUTO)
	Flashing	For 5 seconds when switching from MANU mode to AUTO mode
	Flashing	Generating set in start-up phase
	Fixed	Generating set started
	Fixed	Generating set stabilised (voltage and frequency)
	Flashing (appearance of constant movement from left to right)	The generating set is powering the installation
	Fixed	The installation is supplied
	Not used	
	Not used	

6.3.1.4. Description of the pictograms in zone 2

Alarm and fault pictograms in zone 2

All the pictograms in this zone are activated when TELYS is initialised.

Data displayed			
Fuel level indicator			
Alarm / Fault low fuel level		Alarm / Fault high fuel level	
Coolant level / temperature indicator			
Alarm Low level fault	High level fault alarm	Alarm High temperature fault	No preheating fault alarm
Battery			
Min battery voltage (flashing)	Max battery voltage (flashing)		Battery charge indicator (flashing bars)
Oil pressure / temperature indicator			
Oil pressure Alarm / Fault	High or low oil level Alarm / Fault	High or low oil temperature Alarm / Fault	
Emergency stop			
Emergency stop fault			
Overload or short circuit			
Tripping of circuit breaker following an overload or short circuit			
Engine speed			
Underspeed fault	Overspeed fault		Non-starting fault

6.3.1.5. Description of the pictograms in zone 3

Pictograms in zone 3

All the pictograms in these zones are activated when TELYS is initialised. The pictograms below are given as examples.

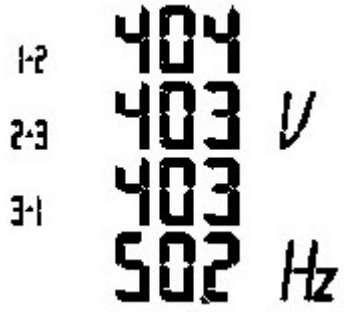
Generating set stopped

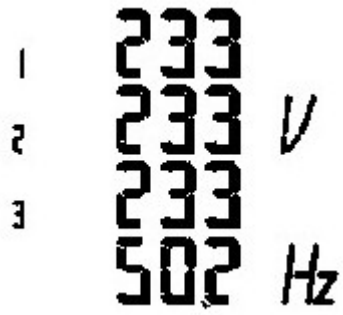
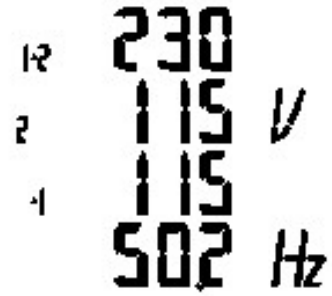
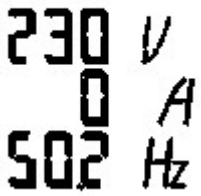
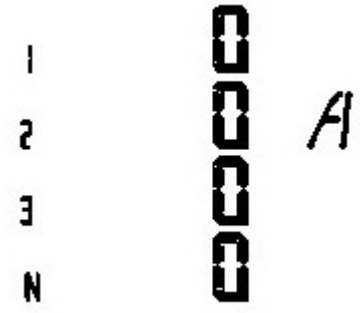
Screen no.	Pictograms	Data displayed
P1		Fuel Level Indicator Indication of Temperature of High Temperature coolant (HT) (units according to settings menu) Indication of Battery Voltage Indication of Oil Temperature (units according to settings menu)

Generating set start-up or generating set started or generating set switching off in progress

Screen no.	Pictograms	Data displayed
P2		Engine Speed Indication Indication of Temperature of High Temperature coolant (units according to settings menu) Indication of Oil Pressure (units according to settings) Indication of Oil Temperature (units according to settings menu)

Generating set started

Screen no.	Pictograms	Data displayed
P3 Default screen in operation		Fuel Level Indicator Alternator composite Voltage Indicator Total Active Power Indicator Alternator Frequency Indicator
P4		U12 Alternator composite Voltage Indicator U23 Alternator composite Voltage Indicator U31 Alternator composite Voltage Indicator Alternator Frequency Indicator

Screen no.	Pictograms	Data displayed
P5		V1 Alternator single Voltage Indicator V2 Alternator single Voltage Indicator V3 Alternator single Voltage Indicator Alternator Frequency Indicator
P6		U12 Alternator composite Voltage Indicator V2 Alternator single Voltage Indicator V1 Alternator single Voltage Indicator Alternator Frequency Indicator
P7		V1 Alternator single Voltage Indicator Single phase Alternator current indicator Alternator Frequency Indicator
P8		Single phase Alternator current indicator Two phase Alternator current indicator Three phase Alternator current indicator Neutral Alternator current indicator
P9		Total Active Power Indicator Total Reactive Power Indicator Total Effective Power Indicator Total Power Factor Indicator (lagging or leading)

Screen no.	Pictograms	Data displayed
P10		Fuel Level Indicator Indication of Battery Voltage Indication of Battery Amps

Screen order of appearance according to network type with the generating set on.

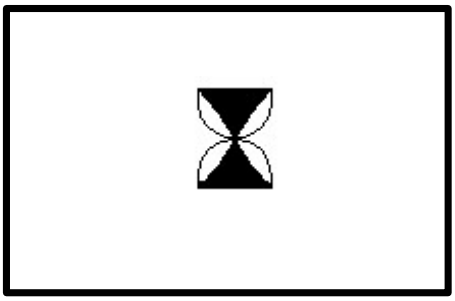
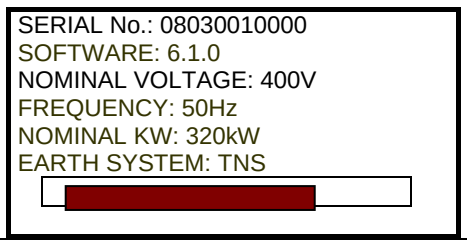
	Type of network			
Order of appearance	**3P+N**	**3P**	**2P+N**	**1P+N**
1	P3	P3	P3	P3
2	P4	P4	P6	P7
3	P5	P8	P8	P9
4	P8	P9	P9	P2
5	P9	P2	P2	P10
6	P2	P10	P10	
7	P10			

Change screens by using the scrolling and selection wheel.
When the wheel is rotated clockwise, the screens scroll upwards and vice-versa.
The screens scroll in a loop.
E.g.: On three-phase + neutral network, then screen 7, then screen 1 and vice-versa.

6.3.1.6. Display of messages in zone 4

The display (zone 4), among other things, displays messages relating to the operation of the generating set. The messages are as follows:

Initialisation of TELYS

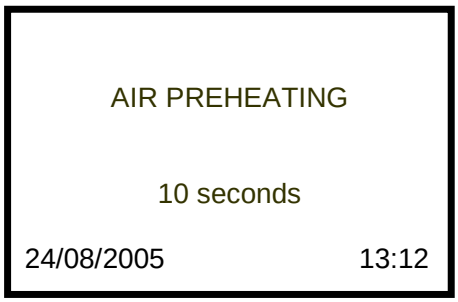
Screen no.	Screen	Data displayed
G 1		Initialisation of TELYS when the power is switched on and/or when loading a configuration
G 2		Generating set serial no. Software version of TELYS Alternator Nominal Voltage Alternator Nominal Frequency Nominal Active Output Neutral Point Bar graph indicating the display delay of the screen

Generating set stopped

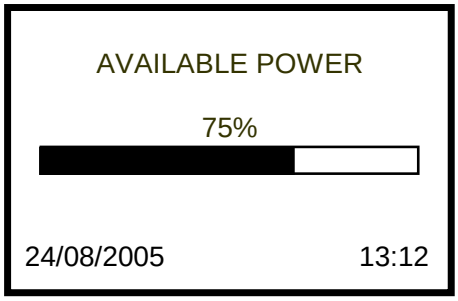
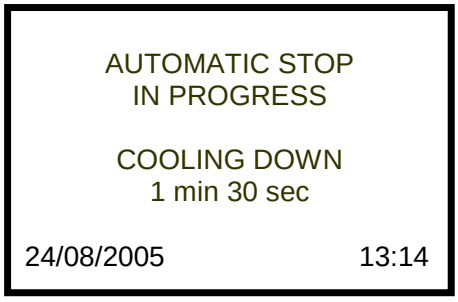
Screen no.	Screen	Data displayed
G 3	OPERATION MANUAL Press START to start 24/08/2005 13:12	Operating mode - generating set in Manual Mode ready to start Date and time (depending on settings)
G 4	OPERATION AUTO WARNING START-UP POSSIBLE IMMEDIATELY 24/08/2005 13:12	Operating mode - generating set in Auto Mode ready to start Date and time (depending on settings)
G 5	WARNING AUTOMATIC Start 19 min 30 sec 24/08/2005 13:12	Operating mode - generating set in Auto Mode with programmed start Countdown to micro disconnection delay or EJP notice delay (for France only) Date and time (depending on settings)

Generating set start-up

Screen no.	Screen	Data displayed
G 6	START-UP IN PROGRESS 24/08/2005 13:12	Operating phase - generating set in starting phase Date and time (depending on settings)

Screen no.	Screen	Data displayed
G 7		Operating phase - air preheating prior to starting generating set Countdown for air preheating delay Date and time (depending on settings)

Generating set started

Screen no.	Screen	Data displayed
G 8 Default screen		Operating phase – generating set in operation – stable voltage and frequency Available power Date and time (depending on settings)
G 9		Operating mode - operation in Auto Mode Opening of power supply device (motorised circuit breaker or source changeover switch controlled by TELYS) Countdown for the mains return delay OR the load test delay Date and time (depending on settings)
G 10		Operating mode - operation in Auto Mode Generation set cooling in progress Countdown for Engine Stop delay (cooling) OR Gradual Stop delay (Coolant temperature) OR Overload Gradual Stop delay OR OFF load test delay Date and time (depending on settings)

Generating setstop

Screen no.	Screen	Data displayed
G 11	OFF IN PROGRESS 24/08/2005 13:16	Generating set stop in progress Date and time (depending on settings)

Operating mode changeover (switching from Manual Mode to Auto Mode following auto start demand)

Screen no.	Screen	Data displayed
G 12	Start Demand AUTO Do you wish to change to Auto Mode? WARNING Immediate start OK Esc	Operating mode - operation in Manual Mode AUTOMATIC start demand

Generating set stop request due to fault or by pressing STOP in Auto Mode

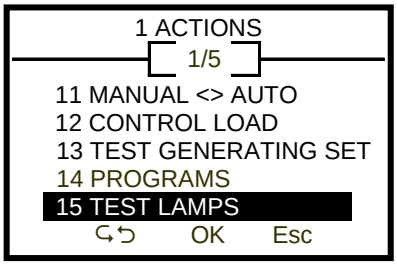
Screen no.	Screen	Data displayed
G 13	Manual Mode activated Do you wish to change to AUTO mode? OK Esc	Operating mode - operation in Auto Mode (generating set in operation) Warning message for switching to Manual Mode after the STOP button has been pressed or a fault has appeared

6.3.2 Starting

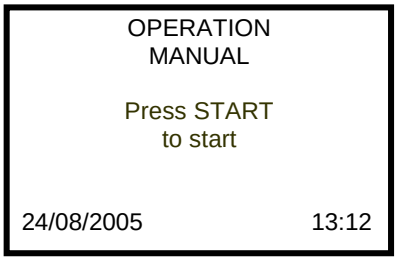
Danger	Check that the generating set circuit breaker has triggered.

❶ Connect the generating set battery
❷ Turn the key switch to the ON position (without forcing it to the ON position), the ON lamp will light up (if the lamp does not light up, check and replace the fuse if necessary)

❸ Test the Alarm and Fault LEDs (menu 15 – TEST LAMPS)

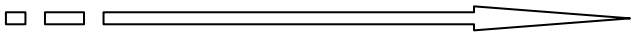


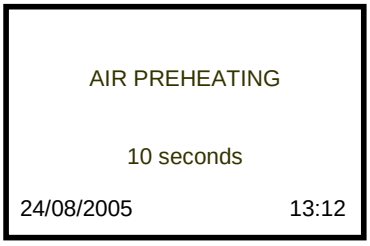
❹ Press "Esc" several times to return to the following home menu



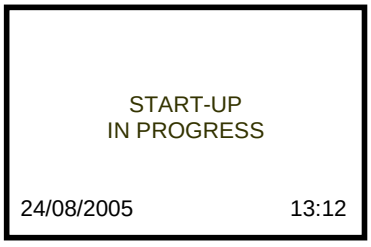
❺Check the battery voltage

❻ Press START:



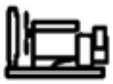


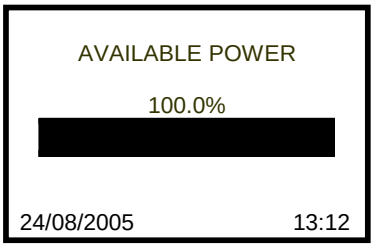
- If the engine is equipped with an air preheating system, there is a delay (adjustable) before the engine starts (preheating activation period).
- If the motor is not fitted with an air preheating system or once the preheating delay has elapsed, the engine starts up (start of a cycle comprising 3 attempts to start up the engine).



Warning: the number of successive and automatic starting attempts is limited to 3.

The following pictogram will flash





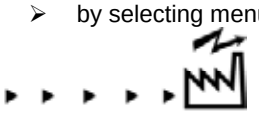
The following pictogram is displayed

The following information is displayed

	Speed of rotation	
	Coolant temperature	Options
	Oil pressure	
	Oil Temperature	

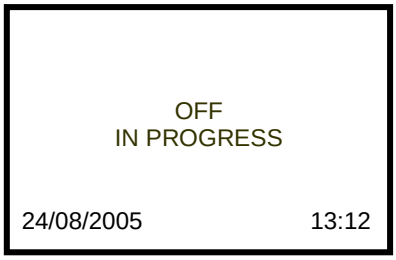
6.3.3 Switching off

❶ Open the circuit breaker
- ➢ manually OR ➢ by selecting menu 12 "CONTROL LOAD"

The following display will disappear (supply stopped) 

❷ Press the STOP button

❸ The following screen is displayed and the generating set will stop



❹ Switch TELYS off by turning the key to "OFF" (without forcing it to the "OFF" position).

6.3.4 Alarms and faults

6.3.4.1. Viewing alarms and faults

Alarms and faults are displayed as follows:

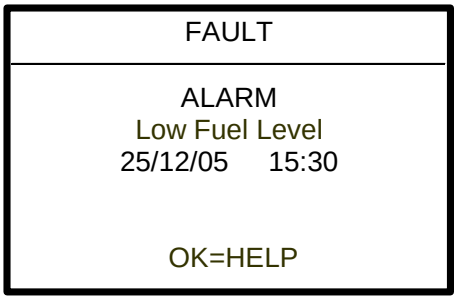
① Alarms

All alarms will cause:

➢ the yellow LED to flash "General alarm".

In conjunction with this LED:
- ➢ a flashing pictogram appears on the LCD screen representing the circuit affected by the alarm and the associated indicator, if present (example)

- ➢ message on graphic display (example)



② Faults

All faults will cause:

- **the generating set to stop: immediate or gradual stop (coolant temperature and overload or short circuit)**
- the red LED to flash "General fault".

In conjunction with this LED:

- a flashing pictogram appears on the LCD screen representing the circuit affected by the fault and the associated indicator, if present (example)

- message on graphic display (example)

FAULT
FAULT Oil Pressure 25/12/05 15:30 OK=HELP

Faults have priority over alarms. Faults are displayed in the descending order of their appearance (from the most recent to the oldest).

6.3.4.2. Activation of an alarm or fault

The appearance of an alarm **or** a fault causes the corresponding screen to be displayed (examples below)

FAULT
ALARM Low coolant Level 06/10/06 10:30 OK=HELP

FAULT
FAULT Emergency Stop 06/10/06 15:30 Esc=RESET OK=HELP

Press OK (on the scrolling and selection wheel) to access the help message if it is available (example below)

HELP
Check the level fuel Esc=EXIT

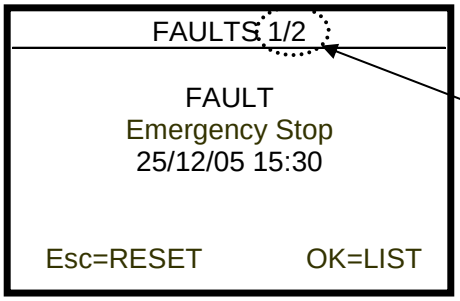
If the alarm is no longer active, it is reset automatically (cause disappears).
Press Esc to reset a fault:

- reset acknowledged if the cause of the fault has been removed
- reset not performed if the cause of the fault is still present.

6.3.4.3. Activation of an alarm and a fault

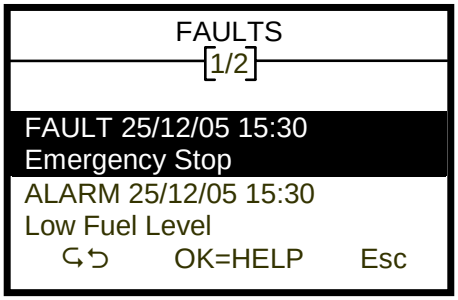
The appearance of an alarm **and** a fault causes:

- The yellow and red LEDs to flash
- the related screen to be displayed (example below)

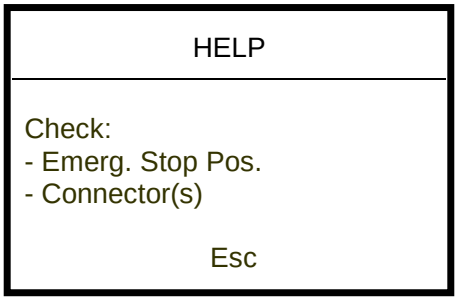


If several faults are present, the number of faults is displayed at the top of the screen.

The faults list can be accessed by pressing OK (of the scrolling and selection wheel) (examples below)



Press Esc to return to the previous screen.
Press OK to go to the HELP screen (help on the highlighted fault)
Use the scrolling and selection wheel to scroll through the list of faults.



If the alarm is no longer active, it is reset automatically (cause disappears).
Press Esc to reset a fault:

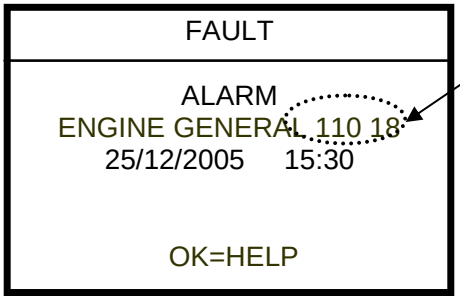
- reset acknowledged if the cause of the fault has been removed
- reset not performed if the cause of the fault is still present.

6.3.4.4. Engine fault codes display

Certain alarms and engine faults generate specific fault codes. These codes are standardised according to the J1939 and/or J1587 standards.

Terminology used by the SAE CAN J1939 standard	
SPN: Suspect Parameter Number	This represents the system or component at fault, for example: SPN 100, indicates an oil pressure problem or a problem with the oil pressure sensor.
FMI: Failure Mode identifier	This represents the type of fault that has occurred. This may be an electrical, mechanical or equipment fault.
Terminology used by VOLVO	
SID: System Identifier	This term, used in the J1587 standard, has an equivalent in the J1939 standard (SPN). However, this term corresponds, more particularly, to an assembly of components, for example, the injection system.
PID: Parameter Identifier	This term, used in the J1587 standard, has an equivalent in the J1939 standard (SPN). However, this term corresponds, more particularly, to a specific component, for example, a sensor.
PPID: Parameter Identifier	This term, used in the J1587 standard, has an equivalent in the J1939 standard (SPN). PPID corresponds to PID, but is only used by VOLVO.
FMI: Failure Mode identifier	This represents the type of fault that has occurred. This may be an electrical, mechanical or equipment fault. VOLVO uses a SID-FMI or PID-FMI or PPID-FMI combination.
Terminology used by JOHN DEERE	
SPN: Suspect Parameter Number	This represents the system or component at fault, for example: SPN 100, indicates an oil pressure problem or a problem with the oil pressure sensor.
FMI: Failure Mode identifier	This represents the type of fault that has occurred. This may be an electrical, mechanical or equipment fault.

In the event of a fault, the screen will display the following message:



Engine fault code.
Pressing OK will display fault finding information.
In addition, appendix D indicate the meaning of the code. The checking and maintenance operations to carry out in order to solve the fault are included in the user and maintenance manuals of the engines supplied with the generating set documentation.

For JOHN DEERE (JD) and VOLVO (VO) engines, the codes displayed are SPN and FMI codes.

6.3.4.5. Horn reset

Depending on the settings made (menu 363 - HORN), the activation of an alarm and/or a fault leads to the horn sounding and the following screen appearing:

This screen will display first any messages relating to the alarms and faults that appear as soon as OK is pressed.

7. Maintenance schedule

7.1. Reminder of use

The maintenance interval frequency and the operations to be carried out are outlined in the maintenance schedule, given as a guideline.
N.B. the environment in which the generating set is operating determines this schedule.
If the generating set is used in extreme conditions, shorter intervals between maintenance procedures should be observed
These maintenance intervals only apply to generating sets running on fuel, oil and coolant which conform to the specifications given in this manual.

7.2. Maintenance safety instructions

Before each operation, please observe the following maintenance safety instructions:

- ✓ read the safety instructions carefully (chapter 1),
- ✓ refer systematically to the maintenance instructions,
- ✓ the battery isolating switch must be in the open position,
- ✓ no operations must be carried out while the motor is running,
- ✓ wear protective equipment (gloves, goggles, safety shoes etc.),
- ✓ before operating on a pressurised circuit, ensure that the circuit pressure has been reduced (atmospheric pressure),
- ✓ after the operations, ensure that the equipment is clean, or clean it if necessary.

7.3. Table of maintenance operations

OPERATIONS	10 h Daily	250 h	500 h	1000 h	1500 h	3000 h	2 years	20 000 h 3 years
Generator set								
• Check the general condition				●				
• Check the tightening torques				●				
• Check the absence of leaks			●					
• Check the condition of battery charge			●					
• Clean the battery terminals			●					
• Check condition and connections of electrical equipment			●					
• Clean with compressed air the relays and contactors			●					
Engine								
• Check engine oil and coolant level	●							
• Check fuel filter / Water bowl	●							
• Check air cleaner	●							
• Replace engine oil and oil filter[a]		●						
• Inspect belt and adjust and belt tension		●						
• Check and Clean radiator fins		●						
• Add grease to link joints, etc.		●						
• Replace fuel filter (in-line type fuel injection pump)			●					
• Inspect valve clearance			●					
• Check glow plug			●					
• Inspect starter				●				
• Inspect alternator				●				
• Retighten bolts and nuts on the engine[a]				●				
• Clean nozzle tip					●			
• Check and Clean fuel injection nozzle						●		
• Inspect turbocharger						●		
• Change coolant							●	
Alternator								
• Check the tightening torques	After the first 20 hours							
• Check the general condition								
• Check the various electrical connections of the installation								
• Grease the bearings								●

[a] After the first 50 service hours for a new or overhauled engine

7.4. Fault finding

Refer to the user manual and engine and alternator maintenance manuals appended.

Additionally, in the event of an abnormal rise in engine temperature, check that the radiator is clean.

7.5. No load and under load tests

Notes on operation at no load and under load:

When operating at no load or low load (< 30% of nominal power), the operating conditions do not allow optimum running of the engine. The main causes are as follows:

- ✓ The low volume of fuel burned in the combustion chamber leads to incomplete combustion; the resulting thermal energy means that the optimum engine operating temperature cannot be reached.
- ✓ Overheated engines have lower compression ratios (low compression ratio without turbocharging), which are defined for full load and not suitable for good combustion at low load.

All of these factors lead to choking of the engine, in particular the piston rings and valves, which leads to:

- ✓ Accelerated wear and glazing of the cylinder liners
- ✓ Loss of sealing of seats, and sometimes sticking of valve stems.

Consequently, operating any turbocharged engine at low load (< 30%) can only have adverse repercussions on an engine's operation and its service life. Maintenance intervals will have to be shortened to accompany harsh operating conditions. Shortening draining intervals, among other things, will enable you to change the oil more frequently, which will tend to be choked with unburnt particles and contaminated with fuel. Adding a load bench is generally used to limit low load phases, and obtain the periodic full loads necessary to unchoke the engine.

Finally, when operating under load, we advise vigilance towards the oil breather circuit, and more particularly towards engines which have the crankcase vent connected to the turbocharger inlet (risk of oil or oil vapour absorption and accelerated engine speed).

On load tests:

It is recommended to conduct an on load test on the generating set monthly, for a period of around 1 hour after stabilisation of the parameters.

The load must be greater than 50% of nominal power (ideally 80%), to ensure unchoking of the engine and to obtain a decent picture of the generating set operation.

Off load test (no load):

This test is not recommended; it must not exceed 10 minutes, and must not be repeated without a monthly on load test. This test only allows you to check for correct engine start-up. It does not allow you to check that the generating set is working properly.

8. Battery

	Fit the battery so that it is properly ventilated. Maintenance should only be carried out by qualified personnel. If replacing the batteries, use the same type of batteries. Do not throw the old battery in the fire. Only use insulated tools (the operator should not be wearing a watch, chain or any metal object). Never use sulphuric acid or acid water to top up the electrolyte level. Use an approved battery fluid. Batteries release oxygen and hydrogen gas, which are flammable. Never bring flames or sparks near the battery (risk of explosion). Discharge any static electricity before handling the batteries by first touching an earthed metal surface. Do not use the battery when the fluid level is below the minimum required level Using a battery with a low electrolyte level could result in an explosion. Do not short the battery terminals with a tool or other metal object. When disconnecting battery cables, remove the cable from the negative (-) terminal first. When reconnecting the battery, connect the positive lead (+) first. Charge the battery in a well-ventilated place, with all the filler caps opened. Ensure that the battery terminals are correctly tightened. A loose cable clamp can cause sparks that could result in an explosion.
Danger	Before servicing electrical components or performing electric welding, set the battery switch to the [OFF] position or disconnect the battery negative cable (-) to cut off the electrical current. Electrolyte contains dilute sulphuric acid. Careless handling of the battery causing contact with sulphuric acid could damage your eyesight or cause burns. Wear safety goggles and rubber gloves when working with the battery (topping-up fluid, charging, etc.) If electrolyte comes into contact with your skin or clothes, wash it off immediately with plenty of water, then carefully wash the area with soap. If electrolyte comes into contact with your eyes, rinse immediately with plenty of water and seek medical attention as soon as possible. If electrolyte is accidentally swallowed, gargle with plenty of water and drink large quantities of water. Consult a doctor immediately. Large quantities of electrolyte should be rinsed off using a neutralising agent. A common method is to use a solution of 500g of bicarbonate of soda diluted in 4 litres of water. The bicarbonate of soda solution should be added until the reaction has finished (lather). The remaining liquid should be rinsed off with water and left to dry.

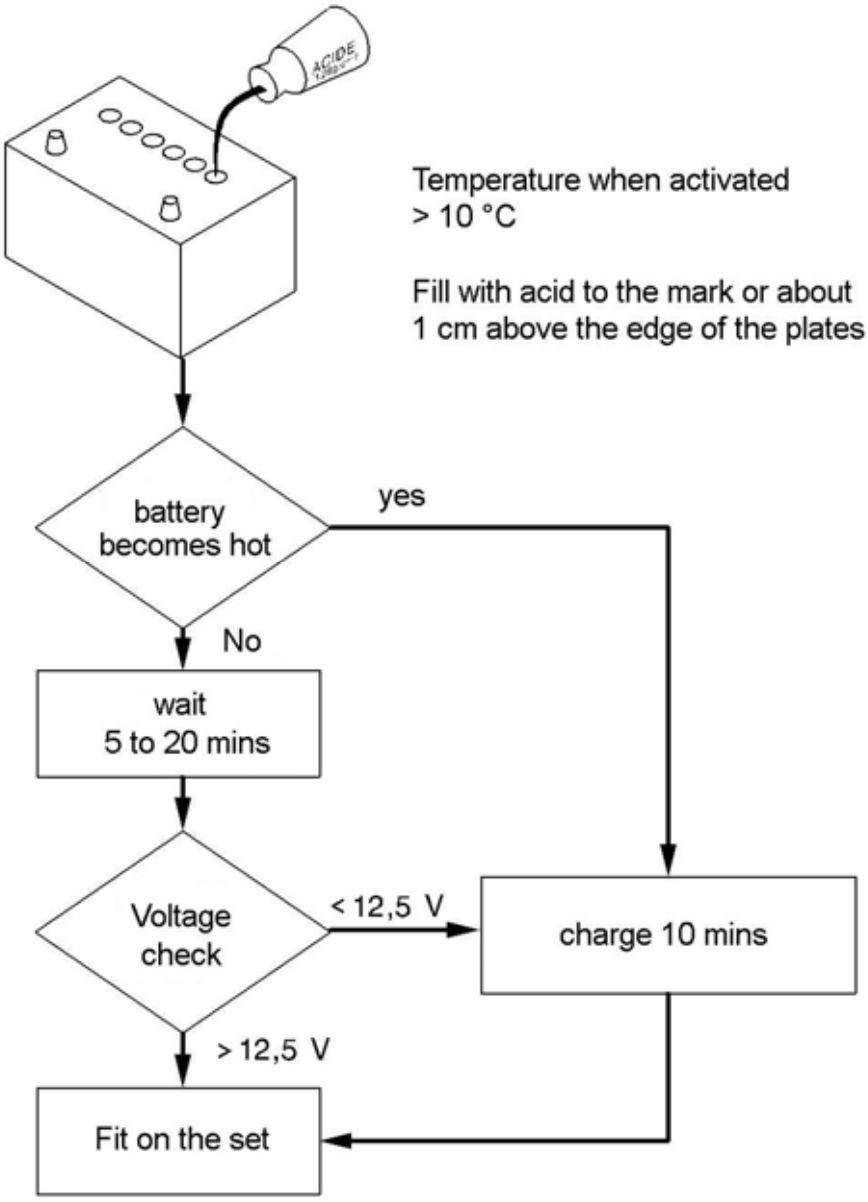
- ✓ Dry batteries do not require any servicing
- ✓ Batteries ready for use must be recharged at the latest when the acid density drops below 1.20.

8.1. Storage and transport

- ✓ Batteries ready for use must be stored in a cool and dry place (frost-free) protected from the sun (self-discharge).
- ✓ Batteries must be transported and stored vertically (risk of acid spillage)
- ✓ Leave the terminal cover on the positive terminal

8.2. Battery setting into service

- Batteries filled with acid have a density of 1.28 g/ml and are charged.
- In the case of dry batteries, fill each battery cell with acid up to the maximum level mark or to 15 mm above the plates. Let the battery rest for 20 minutes.
- Before fitting the battery, stop the engine and any power consumer, clean the terminals and give them a light coating of grease. When connecting, connect the positive terminal (+) first, and then the negative terminal (-).



8.3. Check

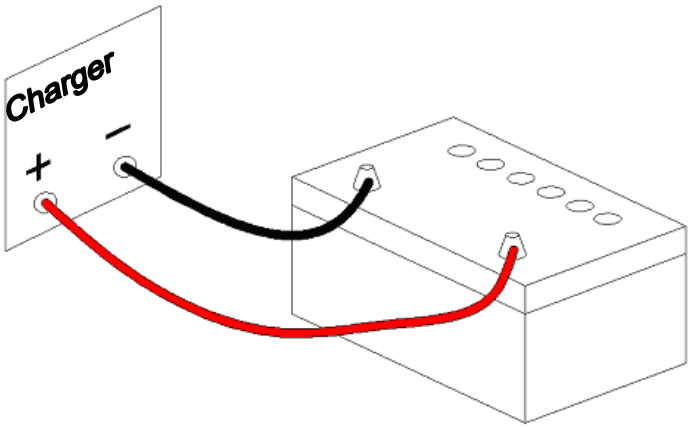
Acid density	Charge status	Voltage when idle	
1.27	100%	Above 12.60 V	
1.25	80%	12.54 V	
1.20	60%	12.36 V	**From 50 % recharge**
1.19	40%	12.18 V	**Risk of sulphation**
1.13	20%	Under 11.88 V	**Unusable**

8.4. Load preconization

✓ Highly discharged or sulphated batteries (formation of whitish lead sulphate deposit on the plates, which becomes hard and insoluble to acid; this deposit reduce the active surface of the plates, and increases their internal resistance) can no longer regenerate or be charged in a generating set.

Important	A discharged battery should be recharged immediately, or else it will suffer irreparable damage.

Battery charge



When several batteries are connected together, the following points should be checked:
✓ Are the batteries connected in series?
✓ Has the correct voltage been chosen? 1 battery x 12 V , 3 x 36V batteries.
✓ Adjust the charge current to the lowest battery.
✓ The power difference between the batteries must be as low as possible.

Example of charge:
✓ 12V 60 Ah battery = charging current 6 A.
✓ Charge status: 50% (acid density 1.21/voltage when idle 12.30V).
✓ The battery is short 30 Ah, and this must be recharged.
✓ Charge factor: 1.2.
✓ Ah x 1.2 = 36 Ah to be charged.
✓ Charging current: 6A approximately 6 hours charging required.

Recharging is complete when the battery voltage and the acid density stop increasing.

→ The charging current must always be $1/10^{th}$ of the nominal capacity of the battery.

The power of the charger must be suitable for the battery to be charged and the charging time available.
You need to use an automatic charger able to provide a sufficient voltage and charging current, as well as a compensation voltage to handle spontaneous battery discharge.

8.5. Faults and remedies

Fault observed	Probable origin	Measures or observations
The acid heats up when a new battery is filled	- Incorrect composition - Incorrect storage - Prolonged storage in a damp place	- Cool - Load - Check the acid density
The acid escapes through the filler holes	- Overfilled battery	- Reduce the battery fluid level
Acid level too low	- Battery tray not leaktight - Excessive charge voltage leading to a significant accumulation of gas.	- Replace the battery - Check the charger and repair if necessary.
Acid level too low Incorrect operation from start-up	- Insufficient charge - Short circuit in the power circuit - Consumption fault	- Recharge - Check the electrical installation
Acid density too high	- The battery has been filled with acid instead of battery fluid	- Reduce the acid level by filling with distilled water. Repeat the operation if necessary.
Starting problems Starting test incorrect	- Battery empty - Battery exhausted or faulty - Capacity too low - Battery sulphated	- Recharge the battery - Fit a new battery
Battery terminals melted	- Incorrect electrical connection - Battery cabling incorrect	- Tighten the ends of the battery cables, or replace them if necessary
One or two cells release a lot of gas at high charge	- Cell(s) faulty	- Fit a new battery
The battery discharges very quickly	- Charge status too low - Short circuit in the current circuit - High self-discharge (through electrolyte contamination etc.) - Sulphation (storage of discharged battery)	- Check the load - Replace the battery
Short service life	- Incorrect battery part no. - Repeated deep discharging - Battery stored too long without charge	- Define the correct battery part no. for the recommended use - It is recommended to charge the battery using a regulator
High water consumption	- Overload - Charging voltage too high	- Check the charger (voltage regulator)
The battery explodes	- Spark after battery charging - Short circuit - Connection or disconnection during charging - Internal fault and low electrolyte level	- Replace the battery - Ventilate well

9. Appendix

9.1. Appendix A – Engine user and maintenance manual

User guide and maintenance manual

MITSUBISHI

Engine

SERIE SS

99610-29120
01/07/2009

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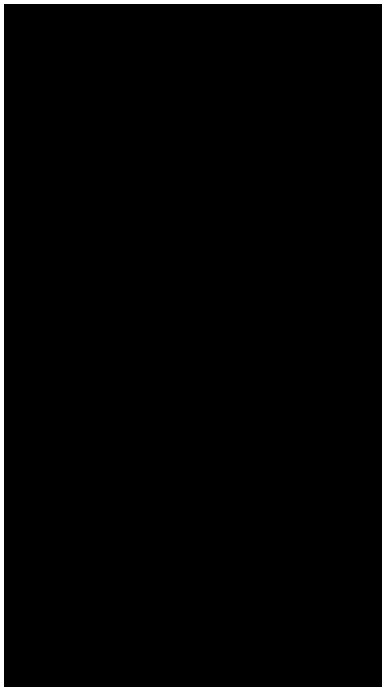
OPERATION & MAINTENANCE MANUAL



MITSUBISHI DIESEL ENGINES

SS-SERIES

The operator and supervisor are requested to read this Operation and Maintenance Manual carefully before operating the engine or conducting inspection and maintenance.
Never operate the engine or conduct maintenance work without completely understanding this manual.

MITSUBISHI HEAVY INDUSTRIES, LTD.

July 2009
Pub. No. 99610-29120

INTRODUCTION

This operation and maintenance manual contains detailed operation, inspection and maintenance information for engines from Mitsubishi Heavy Industries, Ltd.

Please read this manual thoroughly before proceeding with operation, inspection, and maintenance work for correct use and servicing.

Failure to follow directions in this manual may result in serious accidents.

Limited warranty

Mitsubishi Heavy Industries, Ltd. will repair or replace parts returned to us when we judges that the parts are defective in material and/or workmanship after conducting inspection.
Mitsubishi Heavy Industries, Ltd.'s warranty is limited to the compensation work of repair or replacement of parts.
The warranty coverage is effective for the original purchaser only. Those to whom ownership is later transferred are not provided with the warranty.

- **Mitsubishi Heavy Industries, Ltd.'s makes no warranties, either expressed or implied, except as provided in this manual, including, but not limited to, warranties as to marketability, merchantability, fitness for a particular purpose or use, or against infringement of any patent.**
- **Mitsubishi Heavy Industries, Ltd. will not be liable for any damages or consequential damages, including, but not limited to, damages or other costs resulting from any abuse, misuse, misapplication of the engine and devices supplied from us.**
- **Mitsubishi Heavy Industries, Ltd. will not be liable for any damages or personal injuries resulting from any modification, without our written permission, of the engine and devices supplied from us.**
- **Mitsubishi Heavy Industries, Ltd. will not be liable for any damages or production losses caused by the use of fuel, engine oil and/or long life coolant (LLC) that we are not recommended.**
- **The owner of the engine is responsible for the performance of the required maintenance listed in this operation manual.**
  Mitsubishi Heavy Industries, Ltd. may deny the warranty coverage if the engine or part has failed due to inadequate or improper maintenance.

Emission warranty

IMPORTANT

The following warranty applies to the engines that are approved of the emission regulation of the U.S. Environmental Protection Agency.

Warranty coverage

Mitsubishi Heavy Industries, Ltd. warrants to the first owner and each subsequent purchaser of a new non-road diesel engine that the emission control system of your engine:

- is designed, built and equipped so as to conform at the time of sales with all applicable regulation of the U.S. Environmental Protection Agency.If the vehicle in which the engine is installed is registered in the state of California, a separate California emission regulation also applies.
- is free from the defects in material and workmanship which will cause the engine to fail to meet these regulations within the warranty period.

Then its warranty period is

The emission warranty period is shown below.

However, if your engine warranty period is longer than the emission warranty period, the emission warranty period extends to same as the engine warranty period.

Below warranty period shall begin on the date the engine is delivered to the first owner.

If your engine is certified as	And its maximum power is	And its rated speed is	Then its warranty period is
Variable speed or constant speed	kW < 19	Any speed	1,500 hours or 2 years, whichever comes first.
Constant speed	19 ≤ kW < 37	3800 min^{-1} or more	1,500 hours or 2 years, whichever comes first.
Constant speed	19 ≤ kW < 37	Less than 3000 min^{-1}	3000 hours or 5 years, whichever comes first.
Variable speed	19 ≤ kW < 37	Any speed	3000 hours or 5 years, whichever comes first.
Variable speed or constant speed	kW ≥ 37	Any speed	3000 hours or 5 years, whichever comes first.

Warranted parts

Mitsubishi Heavy Industries, Ltd. warrants the parts which will increase the emission of pollutants when they become defective.

The followings are examples.

- Inlet/Exhaust manifold
- Crankcase ventilation system
- Fuel system
- Fuel injection nozzle

LIMITED WARRANTY

Refer to "LIMITED WARRANYT".

California emission control warranty statement your warranty rights and obligations

IMPORTANT

The following warranty applies to the engines that are approved of the emission regulation of the California Air Resources Board (CARB).

The **California Air Resources Board (CARB)** is pleased to explain the **emission control system warranty** on you 2008 or later engine.In California, new heavy-duty off-road engines must be designed, built, and equipped to meet the State's stringent anti-smog standards.Mitsubishi Heavy Industries, Ltd. must warrant the emission control system on your engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the fuel-injection system and the air induction system. Also included may be hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, Mitsubishi Heavy Industries, Ltd. will repair your heavy-duty off-road engine at no cost to you including diagnosis, parts, and labor.

MANUFACTURER'S WARRANTY COVERAGE:

The **2008** and later heavy-duty off-road engines are warranted for the Warranty Period. If any emission-related part on your engine is defective, the part will be repaired or replaced by Mitsubishi Heavy Industries, Ltd.

OWNER'S WARRANTY RESPONSIBILITIES:

- As the heavy-duty off-road engine owner, you are responsible for the performance of the **required maintenance listed in your owner's manual**.Mitsubishi Heavy Industries, Ltd. recommends that you retain all receipts covering maintenance on your heavy-duty off-road engine, but Mitsubishi Heavy Industries, Ltd. cannot deny warranty solely for the lack of receipts or for your failure to ensure the performance of all scheduled maintenance.
- As the heavy-duty off-road engine owner, you should however be aware that Mitsubishi Heavy Industries, Ltd. may deny you warranty coverage if your heavy-dutyoff-road engine or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.
- Your engine is designed to operate on diesel fuel only. Use of any other fuel may result in your engine no longer operating in compliance with California's emissions requirements.
- You are responsible for initiating the warranty process. The Air Rexources Board suggests that you present your heavy-duty off-road engine to a Mitsubishi Heavy Industries, Ltd. dealer or distributor dealer as soon as problem exists. The warranty repairs should be completed by the dealer or distributor as expeditiously as possible.

If you have any questions regarding your warranty rights and responsibilities, you should contact Mitsubishi Engine North America at **1-630-268-0750**.

Warranty coverage

(a) The warranty period shall begin on the date the engine or equipment is delivered to an ultimate purchaser.

(b) Mitsubishi Heavy Industries, Ltd. warrants to the ultimate purchaser and each subsequent purchaser of the engine registered in the state of California that the engine is:

(1) Designed, built and equipped so as to conform with all applicable regulations adopted by the Air Resources Board.

(2) Free from defects in materials and workmanship which cause the failure of a warranted part to be identical in all material respects to the parts as described in Mitsubishi Heavy Industries, Ltd.'s application for certification for a period of 5 years or 3,000 hours of operation, whichever occurs first. In the absence of a device to measure hours of use, the engine shall be warranted for a period of 5 years. For all engines rated less than 19kW, and for constant-speed engines rated under 37 kW with rated speeds higher than or equal to 3,000 min^{-1}, the period of 2 years or 1,500 hours of operation, whichever occurs first, shall apply. In the absence of a device to measure hours of use, the engine shall be warranted for a period of 2 years.

(c) The warranty on emission-related parts shall be interpreted as follows:

(1) Any warranted part which is not scheduled for replacement as required maintenance in the written instructions required by Subsection (e) shall be warranted for the warranty period defined in Subsection (b) (2). If any such part fails during the period of warranty coverage, it shall be repaired or replaced by Mitsubishi Heavy Industries, Ltd. according to Subsection (4) below. Any such part repaired or replaced under the warranty shall be warranted for the remaining warranty period.

(2) Any warranted part which is scheduled only for regular inspection in the written instructions required by Subsection (e) shall be warranted for the warranty period defined in Subsection (b) (2). A statement in such written instructions to the effect of "repair or replace as necessary" shall not reduce the period of warranty coverage. Any such part repaired or replaced under the warranty shall be warranted for the remaining warranty period.

(3) Any warranted part which is scheduled for replacement as required maintenance in the written instructions required in Subsection (e) shall be warranted for the period of time prior to the first scheduled replacement point for that part. If the part fails prior to the first scheduled replacement, the part shall be repaired or replaced by Mitsubishi Heavy Industries, Ltd. according to Subsection (4) below. Any such part repaired or replaced under warranty shall be warranted for the remainder of the period prior to the first scheduled replacement point for the part.

(4) Repair or replacement of any warranted part under the warranty provisions shall be performed at no charge to the owner at a warranty station.

(5) Notwithstanding the provisions of Subsection (4) above, warranty services or repairs shall be provided at all Mitsubishi Heavy Industries, Ltd. distribution centers that are franchised to service the subject engines.

(6) The owner shall not be charged for diagnostic labor that leads to the determination that a warranted part is in fact defective, provided that such diagnostic work is performed at a warranty station.

(7) Mitsubishi Heavy Industries, Ltd. shall be liable for damages to other engine components proximately caused by failure under warranty of any warranted part.

(8) Throughout the engine's warranty period defined in Subsection (b) (2), Mitsubishi Heavy Industries, Ltd. shall maintain a supply of warranted parts sufficient to meet the expected demand for such parts.

(9) Any replacement part may be used in the performance of any maintenance or repairs and must be provided without charge to the owner. Such use shall not reduce the warranty obligations of Mitsubishi Heavy Industries, Ltd..

(10) Add-on or modified parts that are not exempted by the Air Resources Board may not be used. The use of any non-exempted add-on or modified p arts shall be grounds for disallowing a warranty claim. Mitsubishi Heavy Industries, Ltd. shall not be liable to warrant failures of warranted parts caused by the use of a non-exempted add-on or modified part.

(11) The Air Resources Board may request and, in such case, Mitsubishi Heavy Industries, Ltd. shall provide, any documents which describe that Mitsubishi Heavy Industries, Ltd.'s warranty procedures or policies.

(d) Warranted parts list.

(1) Fuel metering system
- (A) Fuel injection system.
- (B) Air/fuel ratio feedback and control system.
- (C) Cold start enrichment system.

(2) Air induction system
- (A) Controlled hot air intake system.
- (B) Intake manifold.
- (C) Heat riser valve and assembly.
- (D) Turbocharger/supercharger systems.
- (E) Charged air cooling systems.

(3) Exhaust gas recirculation (EGR) system
- (A) EGR valve body, and carburetor spacer if applicable.
- (B) EGR rate feedback and control system.

(4) Air injection system
- (A) Air pump or pulse valve.
- (B) Valves affecting distribution of flow.
- (C) Distribution manifold.

(5) Catalyst or thermal reactor system
- (A) Catalytic converter.
- (B) Thermal reactor.
- (C) Exhaust manifold.

(6) Particulate controls
- (A) Traps, filters, precipitators, and any other devices used to capture particulate emissions.
- (B) Regenerators, oxidizers, fuel additive devices, and any other devic e used to regenerate or aid in the regeneration of the particulate control device.
- (C) Control device enclosures and manifolding.
- (D) Smoke puff limiters.

(7) Advances oxides of nitrogen (NOx) controls
- (A) NOx absorbers.
- (B) Lean NOx catalysts.
- (C) Selective catalyst reduction.
- (D) Reductant (urea/fuel) containers/dispensing systems.

(8) Positive crankcase ventilation (PCV) system
- (A) PCV valve.
- (B) Oil filler cap.

(9) Miscellaneous items used in above systems

(A) Vacuum, temperature, and time sensitive valves and switches.

(B) Electronic control units, sensors, solenoids, and wiring harnesses.

(C) Hoses, belts, connectors, assemblies, clamps, fittings, tubing, sealing gaskets or devices, and mounting hardware.

(D) Pulleys, belts and idlers.

(E) Emission control information labels.

(F) Any other part with the primary purpose of reducingemissions or that can increase emission during failure without significantly degrading engine performance.

(e) Mitsubishi Heavy Industries, Ltd. shall furnish with each new engine written instructions for the maintenance and use of the engine by the owner.

LIMITED WARRANTY:

Refer to "LIMITED WARRANTY".

Important information

- To avoid the potential hazard, accident prevention activities must be planned methodically and conducted continually by considering all aspect of engine operation, maintenance and inspection.All related personnel, including managers and supervisors, should actively participate, recognize their roles and organize themselves and their work to ensure a safe environment.
- The foremost safety objective is to prevent accidents which may result in injury or death, or equipment damage.
- Always observe laws or regulations of the local or federal/national government.
- Mitsubishi Heavy Industries, Ltd. cannot foresee all potential dangers of the engine, potential danger resulting from human error and other causes, or danger caused by a specific environment in which the engine is used. Since there are many actions that cannot be performed or must not be performed, it is impossible to indicate every caution in this manual or on warning labels. As such, it is extremely important to follow directions in this manual and also to take general safety measures when operating, maintaining and inspecting the engine.
- When the engine is used by individuals whose native language is not English, the customer is requested to provide thorough safety guidance to the operators.Also add safety, caution and operating signs that describe the original warning label statements in the native language of the operators.
- The engine must be operated, maintained and inspected only by qualified persons who have thorough knowledge of engines and their dangers and who also have received risk avoidance training.
- To prevent an accident, do not attempt to carry out any operation other than those described in this manual, and do not use the engine for any unapproved purpose.
- When the ownership of the engine is transferred, be sure to provide this manual with the engine to the new owner. Also inform Mitsubishi Heavy Industries, Ltd. of the name and address of the new owner of the engine.
- This manual is copyrighted and all rights are reserved.No part of this manual, including illustrations and technical references, may be photocopied, translated, or reproduced in any electronic medium or machine readable form without prior written consent from Mitsubishi Heavy Industries, Ltd.
- The contents in this manual are subject to change at any time without notice for improvement of the engine.
- Pictures or illustrations of the product in this manual may differ from those of product you have. Please note that, depending on specifications, items described in this manual may differ from those on your engine in shape, or may not be installed on your engine.
- Please contact a dealer of Mitsubishi Heavy Industries, Ltd. if you need more information or if you have any questions.
- If you lost or damaged this manual, obtain a new copy at a dealer of Mitsubishi Heavy Industries, Ltd. as soon as possible.
- Mitsubishi Heavy Industries, Ltd. recommends the engine owner to install an hour meter on the engine due to monitor correct running intervals and to perform the maintenance at the appropriate timing.

Warning indication

The following means are used to call the attention of the operators and maintenance personnel to potential dangers of the engine.

- Warning statements in the manual
- Warning labels affixed on the engine

Warning statements

The warning statements in this manual describe potential danger in operating, inspecting or maintaining the engine, using the following 5 classifications to indicate the degree of potential hazard.

Failure to follow these directions could lead to serious accidents which could result in personal injury, or death in the worst case.

Understand the directions well, and handle engines with following directions.

DANGER	Indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.
CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in property damage.
Note :	Indicates important information or information which is useful for engine operation.

Units of measurement

Measurements are based on the International System of Units (SI), and they are converted to the metric system units in this manual using the following conversion rates.

- Pressure :1 MPa = 10.197 kgf/cm^2
- Torque :1 N·m = 0.10197 kgf·m
- Force :1 N = 0.10197 kgf
- Horsepower :1 kW = 1.341 HP = 1.3596 PS
- Meter of mercury :1 kPa = 0.75 cmHg
- Meter of water :1 kPa = 10.197 cmH_2O(cmAq)
- Engine speed :1 min^{-1} = 1 rpm
- Kinetic viscosity:1 mm^2/s = 1 cSt

Abbreviations, standards and others

- API = American Petroleum Institute
- ASTM = American Society for Testing and Materials
- ISO = International Organization for Standardization
- JIS = Japanese Industrial Standards
- LLC = Long Life Coolant
- MIL = Military Specifications and Standards
- MSDS = Material Safety Data Sheet
- SAE = Society of Automotive Engineers

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Chapter 1 BASIC SAFETY PRECAUTIONS

Fire and explosions

⚠ WARNING

Keep flames away

Do not use flames near the engine (in the engine room). Fuel vapor or other gas can catch fire and produce dangerous situations.

Wipe off spilled fuel, oil and LLC immediately and thoroughly. Spilled fuel, oil and LLC may ignite and cause a fire.

Store fuel and engine oil in a well-ventilated area. Make sure that the caps of fuel and engine oil containers are tightly closed.

Keep engine surrounding area tidy and clean

Do not leave combustible or explosive materials, such as fuel, engine oil and LLC, near the engine. Such substances can cause fire or explosion.

Remove dust, dirt and other foreign materials accumulated on the engine and surrounding parts thoroughly. Such materials can cause fire or the engine to overheat. In particular, clean the top surface of the battery thoroughly. Dust can cause a short-circuit.

Care for fuel, oil and exhaust gas leakage

If any fuel, oil or exhaust gas leakage is found, immediately take corrective measures to stop it.

Such leakages, if left uncorrected, can cause fuel or engine oil to reach hot engine surfaces or hot exhaust gas to contact flammable materials, possibly leading to personal injury and/or damage to equipment.

Use explosion-proof lighting apparatus

When inspecting fuel, engine oil, coolant, battery electrolyte, etc., use a flameproof light. An ordinary lighting apparatus may ignite gas and cause it to explode.

Prevent electrical wires from short-circuiting

Avoid inspecting or servicing the electrical system with the ground cable connected to the battery. Otherwise, a fire could result from short-circuiting. Be sure to disconnect the battery cable from the negative (-) terminal before beginning with the work procedure.

Short-circuits, possibly resulting in fire, may be caused by a loose terminal or damaged cable/wire. Inspect the terminals, cables and wires, and repair or replace the faulty parts before beginning with the service procedure.

Keep fire extinguishers and a first-aid kit handy

Keep fire extinguishers handy, and become familiar with their usage.

Keep a first-aid kit at the designated place where it is easily accessible by anyone at any time.

Establish response procedures to follow in the event of fire or accident. Provide an emergency evacuation route and contact points and means of communication in case of emergency.

Stay clear of all rotating and moving parts

⚠ WARNING

Install protective covers around rotating parts

Make sure the protective covers of the engine are correctly installed.
Repair any damaged or loose covers.
Never remove the covers such as damper cover, camshaft cover, or rocker cover that enclose the revolving parts during operation.
When the engine is coupled to driven equipment, be sure to provide protective covers over the parts such as the connecting belts and couplings that are exposed.
Never remove protective covers.

Check work area for safety

Before starting the engine, make sure no one is near the engine and tools are not left on or near the engine.
Verbally notify persons within the immediate area when starting the engine.
When the starter device is posted with a sign that prohibits startup operation, do not operate the engine.

Stay clear of moving parts while engine is running

Do not approach rotating or sliding parts of the engine while the engine is running. Keep objects likely to be caught by rotating parts away from such parts.
If any part of the clothing or outfitting is caught by a rotating part, serious bodily injuries could result.

Lockout and tagout

Be sure to lockout and tagout before starting inspection and maintenance.
Lockout and tagout are effective methods of cutting off machines and equipment from energy sources.
To accomplish the lockout/tagout, remove the starter switch key, set the battery switch to "OFF" position and attach a "Do Not Run" or similar caution tag to the starter switch.
The starter switch key must be kept by the person who performs inspection and maintenance during the work.

Keep engine stopped during servicing

Be sure to stop the engine before proceeding to inspection and service procedure. Never attempt to make adjustments on the engine parts while the engine is running.
Rotating parts such as belt can entangle your body and cause serious injuries.

Always restore engine turning tools after use

Be sure to remove all turning tools used during maintenance and inspection work. Remember also that the turning gear must be returned to the operating condition before starting the engine.
Starting the engine with the turning tools inserted or with the turning gear in engagement can lead to not only engine damage but also personal injuries.

Changing the engine speed setting is prohibited

Never change engine speed setting. Tampering with the setting can cause the engine and its coupled machine to operate at excessive speeds and result in accidents.

Be careful of exhaust fume poisoning

WARNING

Operate engine in a well-ventilated area

If the engine is installed in an enclosed area, and the exhaust gas is ducted outside, ensure that there is no exhaust gas leakage from duct joints.

When using the engine as portable generator set, do not run it in doors such as a warehouse or tunnel, or in an poorly-ventilated area near the shielding. When running it indoors by necessity, discharge the exhaust gas to outside and thoroughly ventilate the room.

Make sure the exhaust gas is not discharged directly to surrounding buildings, plants or living passersby.

Exhaust gas from the engine contains carbon monoxide and other harmful substances. Operating the engine in an poorly-ventilated area can produce gas poisoning.

Be careful of falling down

WARNING

Lift engine carefully

To lift the engine, use slings capable of supporting the weight of the engine.

Attach the wire rope to the hangers provided on the engine using a correct sling.

During lifting process, keep the engine in a well-balanced position by taking the center of gravity of the engine into consideration.

Keep the angle formed by slings attached to hangers within 60°. If the angle exceeds this limit, excessive load could be imposed on the hangers and this could damage the hangers and result in a serious accident.

If the wire rope contacts the engine directly, place a cloth or other soft padding to avoid damage to the engine and wire rope.

Do not climb onto the engine

Do not climb onto the engine, nor step on any engine parts located on the lateral sides.

To work on parts located on the upper section of engine, use a ladder, stool, etc., that was firmly secured.

Climbing on the engine may not only damage engine parts but also cause falling down from the engine and result in personal injuries.

Always prepare stable scaffold

When working on the upper part of the engine and other hard-to-reach places, use a stable work platform. Standing on a decrepit stool or parts box may result in personal injury.

Do not place any unnecessary objects on a work platform.

Protect ears from noise

⚠ CAUTION

Wear ear plugs

Always wear ear plugs when entering the machine room (engine room). Combustion sound and mechanical noise generated by the engine can cause hearing problems.

Be careful of burns

⚠ CAUTION

Do not touch the engine during or immediately after operation

To avoid burns, do not touch the engine during or immediately after operation.

A hot engine can cause burns.

To conduct maintenance and inspection work, wait until the engine has cooled sufficiently by checking the temperature gauge.

Do not open the radiator filler cap when the engine is hot

Never open the radiator filler cap while the engine is running or immediately after the engine is stopped.

When opening the cap, stop the engine and allow the coolant temperature to lower sufficiently.

When opening the radiator filler cap, open slowly to discharge the pressure inside the tank. Also to avoid a risk of getting scalded by steam, wear thick rubber gloves or wrap a cloth around the cap.

When closing the cap, be sure to tighten securely.

The coolant is hot while engine is running and immediately after the engine stops. If the cap is opened when the coolant is at operating temperature, steam and hot coolant may blow out and result in burns.

Do not touch high pressure injection fuel

If fuel leaks or sprays out from the high pressure injection pipe, do not touch the fuel.

Fuel in the fuel injection pipes is under high pressure and if the fuel contact your skin, it goes into deep tissues and may result gangrene.

Refill coolant only after the coolant temperature dropped

When refilling of coolant, perform it after coolant temperature drops, not immediately after the engine is stopped. Otherwise you are scalded with hot coolant.

Be careful when handling fuel, engine oil or LLC

⚠ CAUTION

Use only specified fuel, engine oil and LLC

Use fuel, oil and LLC specified in this manual, and handle them carefully.

Use of any other fuel, oil or LLC, or improper handling may cause various engine problems and malfunctions.

Obtain the MSDS issued by the fuel, oil and LLC suppliers, and follow the directions in the MSDSs for proper handling.

Handle LLC carefully

When handling LLC, always wear rubber gloves and a protective face mask. If LLC or cooling water containing LLC comes into contact with your skin or eyes, or if it is swallowed, you would suffer from inflammation, irritation or poisoning.

Should LLC be accidentally swallowed, induce vomiting immediately and seek medical attention. Should LLC enter your eyes, flush them immediately with plenty of water and seek medical attention. If LLC splashes onto your skin or clothing, wash it away immediately with plenty of water.

Keep flames away from LLC. The LLC can catch flames, causing a fire. Coolant (containing LLC) drained from the engine is toxic. Never dispose of coolant into regular sewage. Abide by the applicable law and regulations when discarding drained coolant.

Proper disposal of waste oil, LLC and coolant

Do not discharge waste engine oil, LLC and coolant into sewerage, river, lake or other similar places. Such a way of disposal is strictly prohibited by laws and regulations.

Dispose of waste oil, LLC and coolant and other environmentally hazardous waste in accordance with the applicable law and regulations.

When abnormality occurs

⚠ CAUTION

Do not add coolant immediately after a sudden stop due to overheating

If the engine stops suddenly or if you have no choice but stop the engine suddenly due to overheating, do not add coolant immediately.

Adding water while the engine is hot can damage parts such as cylinder heads due to a sudden drop of temperature. Add coolant gradually after the engine has completely cooled.

Avoid immediate restart after abnormal stop

If the engine stops abnormally, do not restart the engine immediately. If the engine stops with an alarm, check and remedy the cause of the problem before restarting. Sustained use of the engine without any remedy could result in serious engine problems.

Avoid continuous engine operation at low oil pressure

If an abnormal engine oil pressure drop is indicated, stop the engine immediately, and inspect the lubrication system to locate the cause. Continuous engine operation with low oil pressure could cause bearings and other parts to seize.

If belt breaks, stop engine immediately

If the belt breaks, stop the engine immediately. Continuous engine operation with the broken belt could cause the engine to overheat and thereby the coolant to boil into steam, which may gush out from the reserve tank or radiator, and you may be scalded with it.

Service battery

⚠ CAUTION

Handle the battery correctly

- Never use flames or allow sparks to generate near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks in the vicinity could cause an explosion.
- Do not use the battery when the battery electrolyte level of which is below "LOWER LEVEL" line. Sustained use of the battery could result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When removing battery, always remove the plug from the negative (-) terminal first. When connecting battery, always connect the plug to the positive (+) terminal first.
- Remove all plugs, then charge the battery in a well-ventilated area.
- Make sure the cable clamps are securely installed on the battery terminals. A loose cable clamp can cause sparks that may result in an explosion.
- Before servicing electrical components or conducting electric welding, set the battery switch to the "Open/OFF" position or remove the plug from the negative (-) terminal to cut off the electrical current.
- Battery electrolyte contains dilute sulfuric acid. Careless handling of the battery can cause the loss of sight and/or skin burns. Also, do not consume the battery electrolyte.
- Wear protective goggles and rubber gloves when working with the battery (when adding water, charging, etc.)
- If battery electrolyte is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to thoroughly clean.
- The battery electrolyte can cause the loss of sight if splashing into the eyes. If it gets into the eyes, immediately flush it away with plenty of clean water, and seek immediate medical attention.
- If the battery electrolyte is accidentally consumed, gargle with plenty of water, then drink lots of water, and seek immediate medical attention.

Other cautions

⚠ CAUTION

Never modify engine

Unauthorized modification of the engine will void our warranty.

Modification of the engine may not only cause engine damage but also produce personal injuries.

If there is a need to modify the engine, contact a dealer of Mitsubishi Heavy Industries, Ltd.

Observe safety rules at work site

Observe the safety rules established at your workplace when operating and maintaining the engine.

Do not operate the engine if you are feeling ill, inform your supervisor of your condition. Operation of the engine with reduced awareness may cause improper operation that could result in accidents.

When working in a team for two or more people, use specified hand signals to communicate among workers.

Work clothing and protective gear

Wear a hardhat, face shield, safety shoes, dust mask, gloves and other protective gear as needed. When handling compressed air, wear safety goggles, a hardhat, gloves and other necessary protective gear.

Works without wearing proper protective gear could result in serious injuries.

Never break seals

To ensure proper engine operation, the fuel control linkage is sealed to prevent accidental change of the injection volume and rotation speed settings. Operating the engine without these seals in place can cause problems described below, and also invalidates the warranty.

- Rapid wear of sliding and rotating parts
- Engine damage such as seizing of engine parts
- Considerably increased consumption of fuel and lubricating oil
- Degradation of engine performance due to improper balance between fuel injection volume and governor operation or overrunning of the engine which could result in a serious accident

Perform all specified pre-operation inspections and periodic inspections

Conduct the pre-operation inspections and periodic inspections as described in this manual.

Failure to conduct the specified inspections may cause various engine problems, damage to parts, and serious accidents.

Break-in the engine

To break-in new engines or overhauled engines, operate the engine at a speed lower than the rated speed in a light load condition during the first 50 hours of operation.

Operating new engines or overhauled engines in a severe condition during the break-in period shortens the service life of the engine.

Warm up the engine before use

After starting the engine, run the engine at low idling speeds for 5 to 10 minutes for warm up. Start the work after this operation is completed. Warm up operation circulates the lubricant through the engine. Therefore, individual engine parts are well lubricated before they are subjected to heavy loads.

Warm up operation circulates lubricants in the engine and contributes to a longer service life and economical operation.

Do not conduct warm up operation for prolonged period of time. Prolonged warm up operation causes carbon build-up in the cylinders that leads to incomplete combustion.

Never operate the engine in an overloaded condition

If the engine shows an overloaded condition such as black exhaust smoke, reduce the load immediately to operate the engine at an appropriate output and load.

Overloading causes not only high fuel consumption but also excessive carbon deposits inside the engine. Carbon deposits cause various problems and will shorten the service life of the engine.

Conduct cooling operation before stopping the engine

Before stopping the engine, let it idle in low gear for 5 to 6 minutes to cool down.

Stopping the engine immediately after high-load operation will cause engine parts to heat up and shorten the service life of the engine.

During cooling operation, check the engine for abnormalities.

Protection of the engine against water entry

Do not allow rainwater, etc. to enter the engine through the air inlet or exhaust openings.

Do not wash the engine while it is operating. Cleaning fluid (water) can be sucked into the engine.

Starting the engine with water inside the combustion chambers can cause the water hammer action which may result in internal engine damage and serious accidents.

Properly maintain the air cleaner and pre-cleaner

Maintain the engine with air cleaner or pre-cleaner according to the following instructions.

- Do not maintain the air cleaner or pre-cleaner while the engine is running. The turbocharger may suck particles of foreign materials into the engine and could result in serious accidents.
- Remove the air cleaner or pre-cleaner slowly to prevent foreign materials accumulated on the element from falling off. After removing the air cleaner or pre-cleaner, immediately cover the opening (inlet port of air cleaner; port in body for pre-cleaner) with plastic sheet or similar means to prevent foreign materials from entering the engine.
- Clean the pre-cleaner periodically. The pre-cleaner clogging can cause insufficient intake air or increasing in the exhaust temperature.
- If the engine is equipped with a dust indicator, conduct maintenance when the clog warning sign appears.

Use of tools optimum for each work

Always keep in mind to select most appropriate tools for the work to be performed and use them correctly. If tools are damaged, replace them with new tools.

Avoidance of prolonged time of starter operation

Do not use the starter for more than 10 seconds at a time. If the engine does not start, wait for at least 1 minute before cranking again.

Continuous operation of the starter will drain the battery power and cause the starter to seize.

Do not turn off the battery switch during operation

Do not turn off the battery switch during operation.

If the battery switch is turned OFF when the engine is running, not only various meters will stop working but also the alternator may have its diode and transistor deteriorated.

Cautionary instructions for transporting the engine

When transporting the engine on a truck, consider the engine weight, width and height to ensure safety.

Abide by road traffic law, road vehicles act, vehicle restriction ordinance and other pertinent laws.

Chapter 2 NAME OF PARTS

Engine external diagrams

The external diagram is for the standard type of the engine. The installed equipment and shapes differ according to the engine type.

S4S in-line type fuel injection pump left view

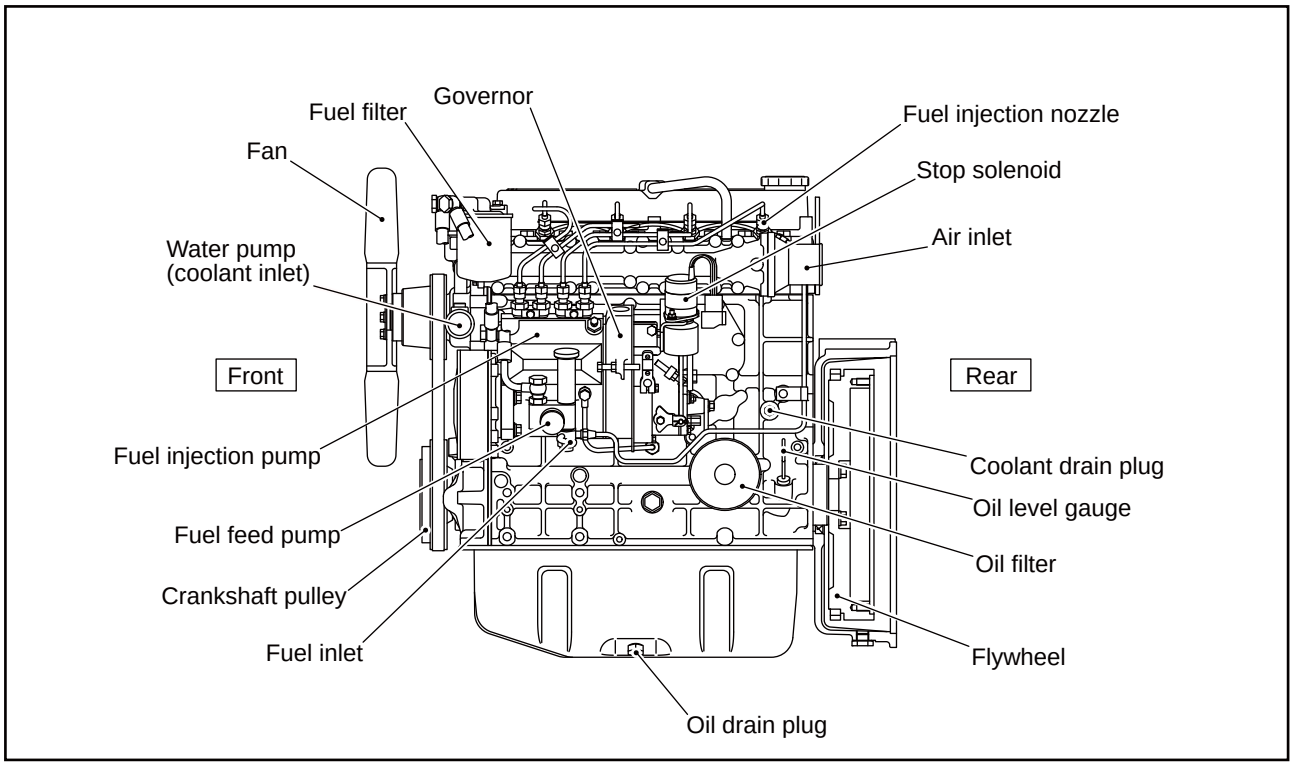


Fig. 2-1 Engine left view

S4S in-line type fuel injection pump right view

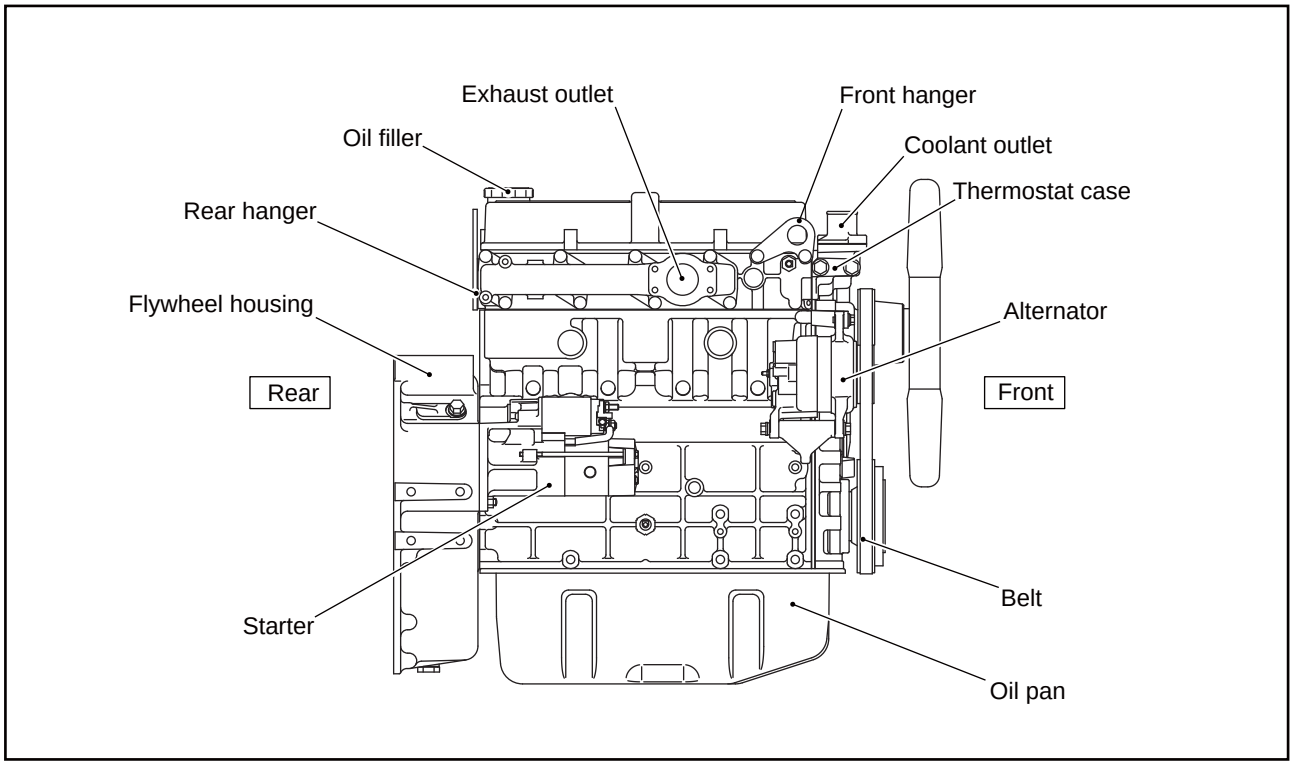


Fig. 2-2 Engine right view

S4S-DT in-line type fuel injection pump left view

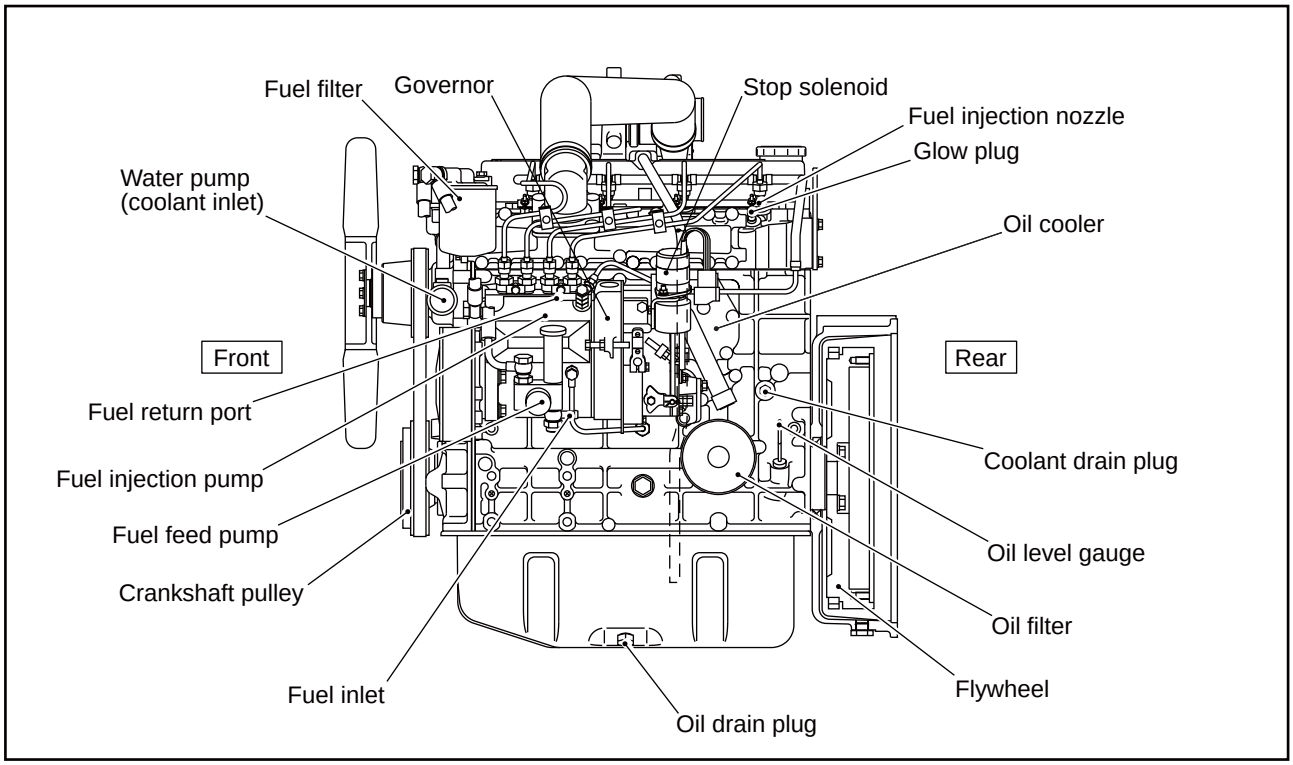


Fig. 2-3 Engine left view

S4S-DT in-line type fuel injection pump right view

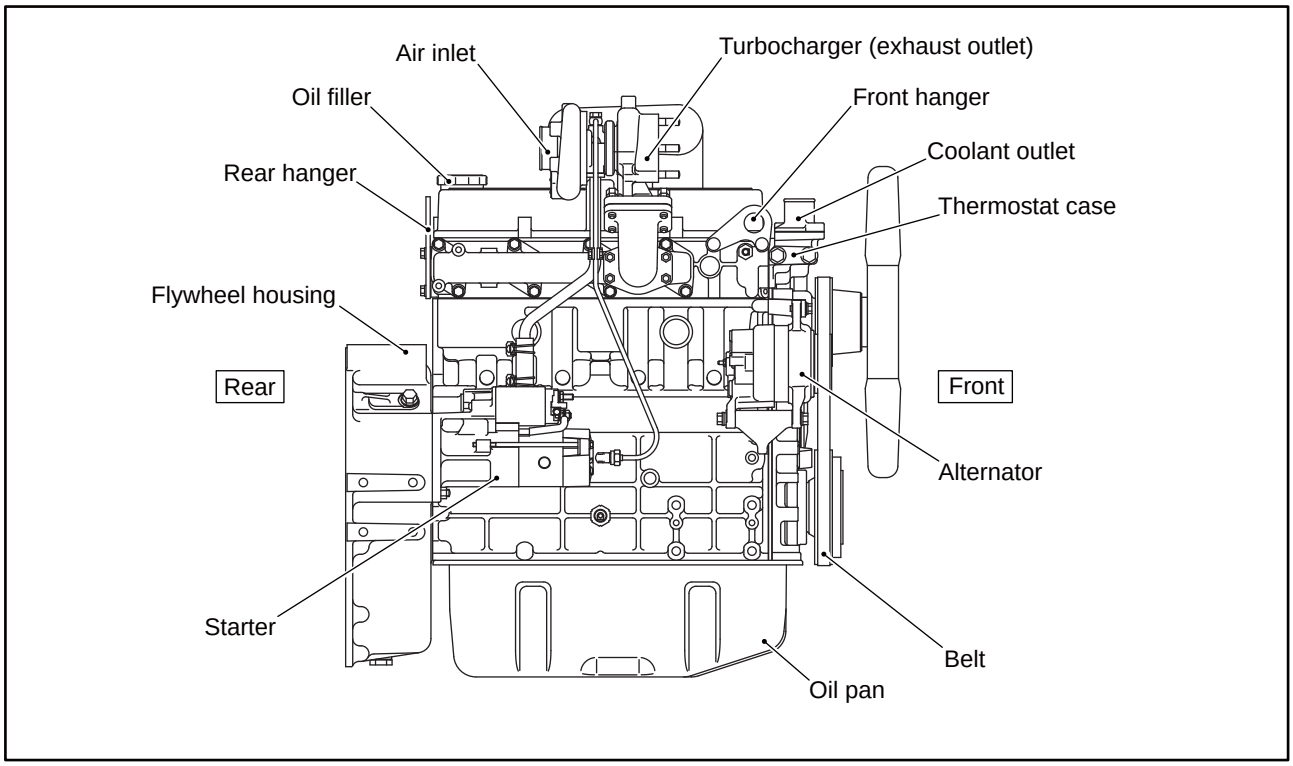


Fig. 2-4 Engine right view

S4S distoributor type fuel injection pump left view

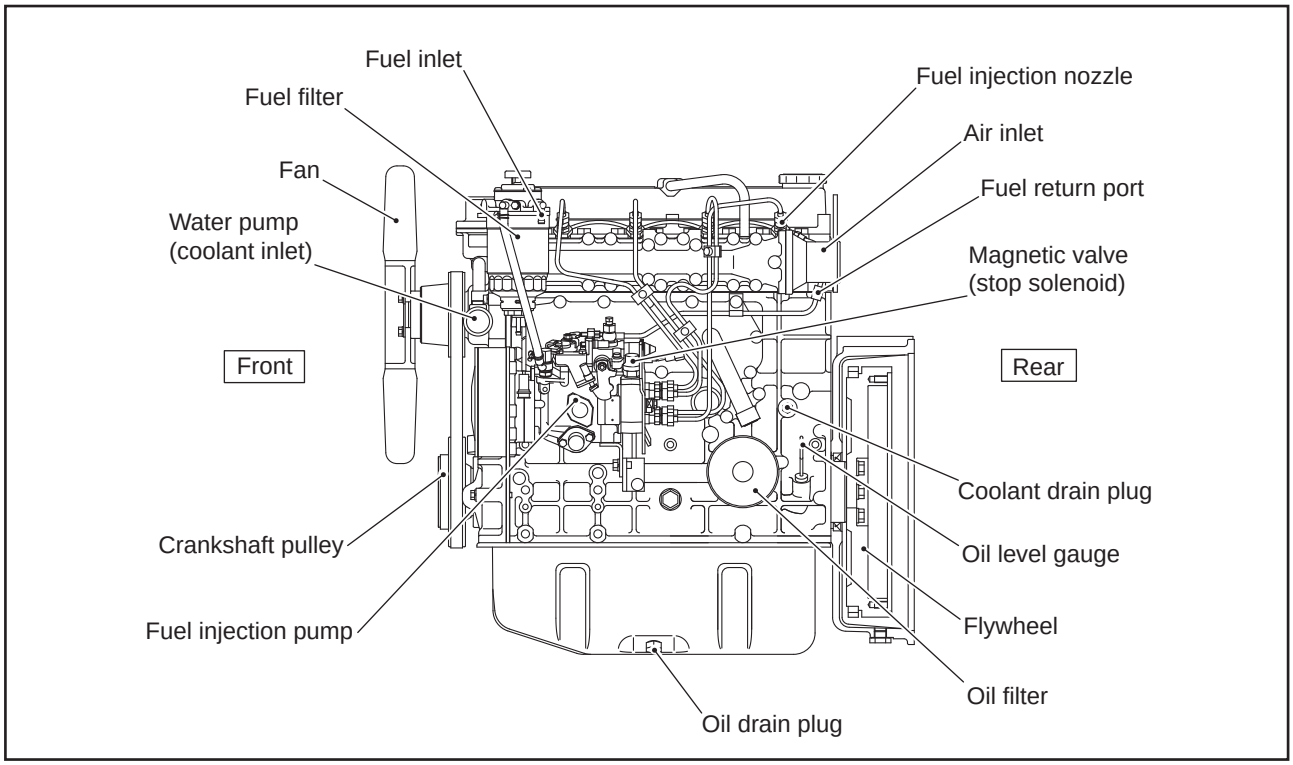


Fig. 2-5 Engine left view

S4S distoributor type fuel injection pump right view

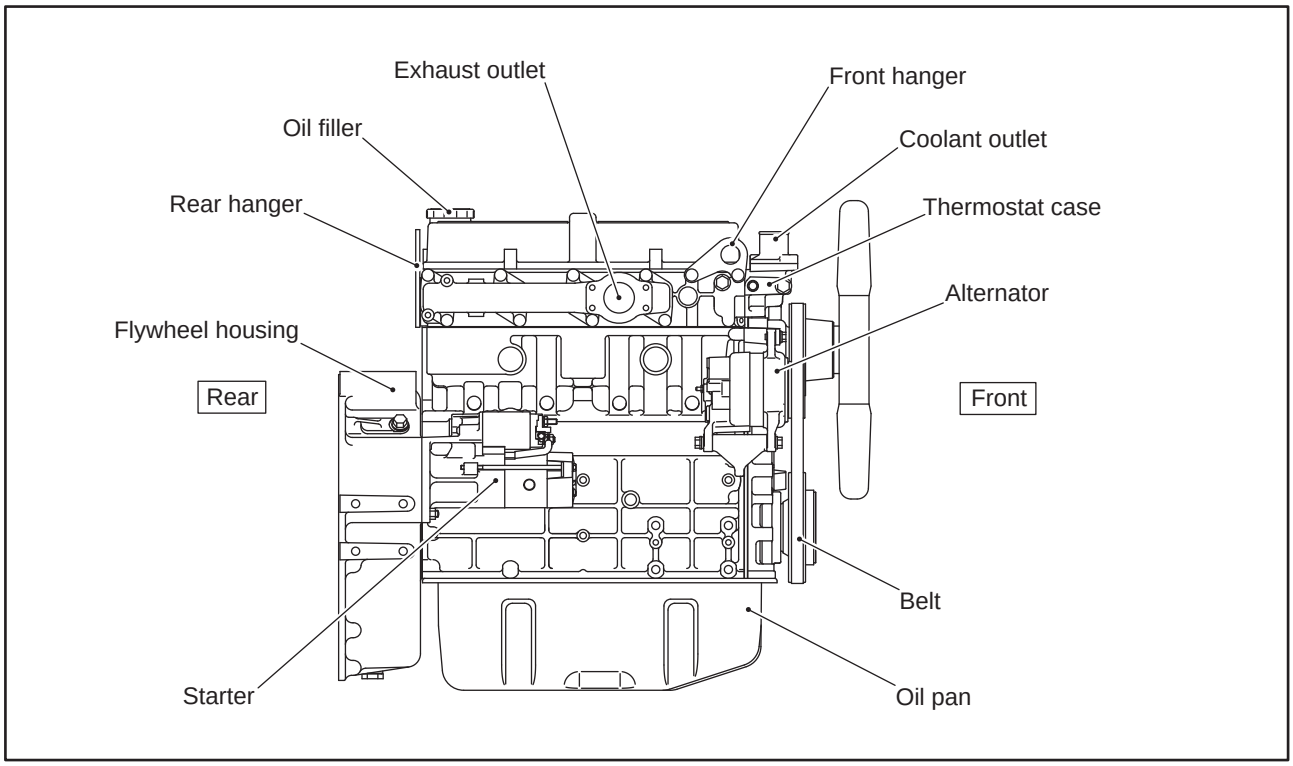


Fig. 2-6 Engine right view

S4S-DT distoributor type fuel injection pump left view

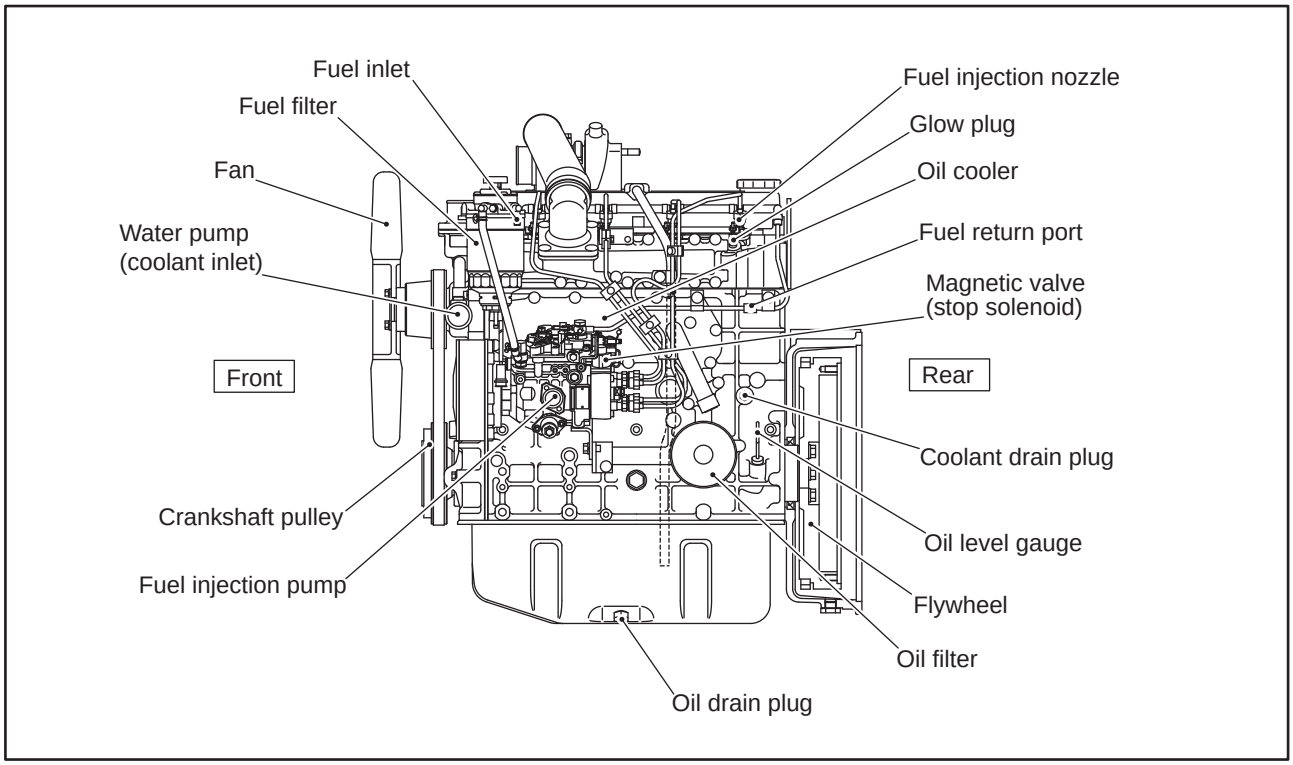


Fig. 2-7 Engine left view

S4S-DT distoributor type fuel injection pump right view

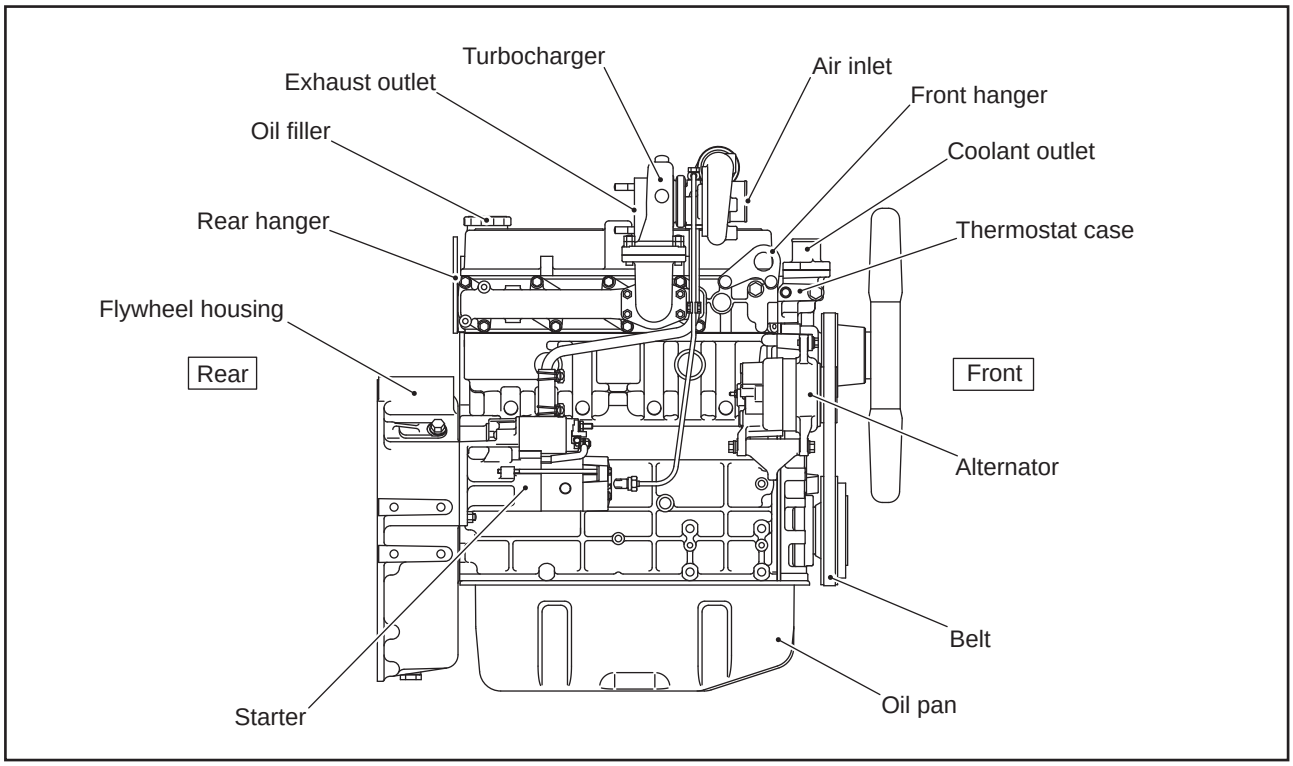


Fig. 2-8 Engine right view

S6S in-line type fuel injection pump left view

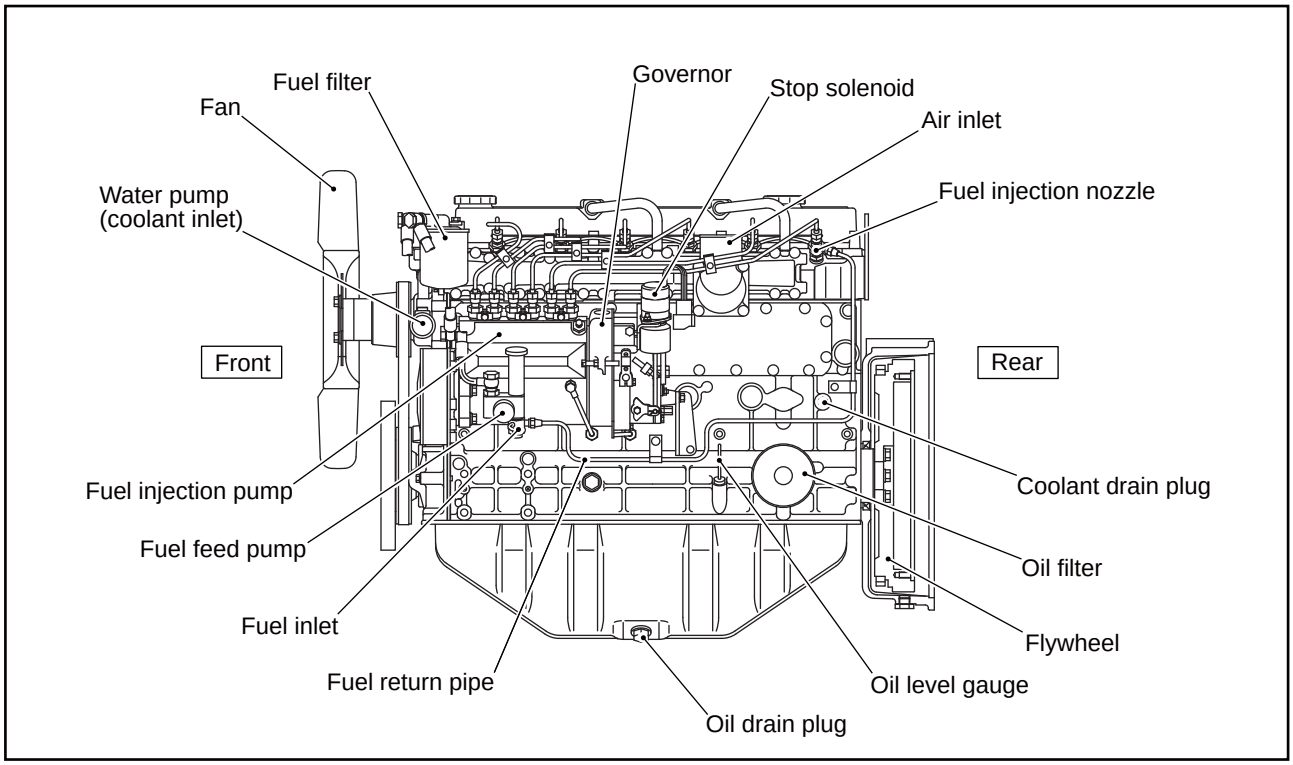


Fig. 2-9 Engine left view

S6S in-line type fuel injection pump right view

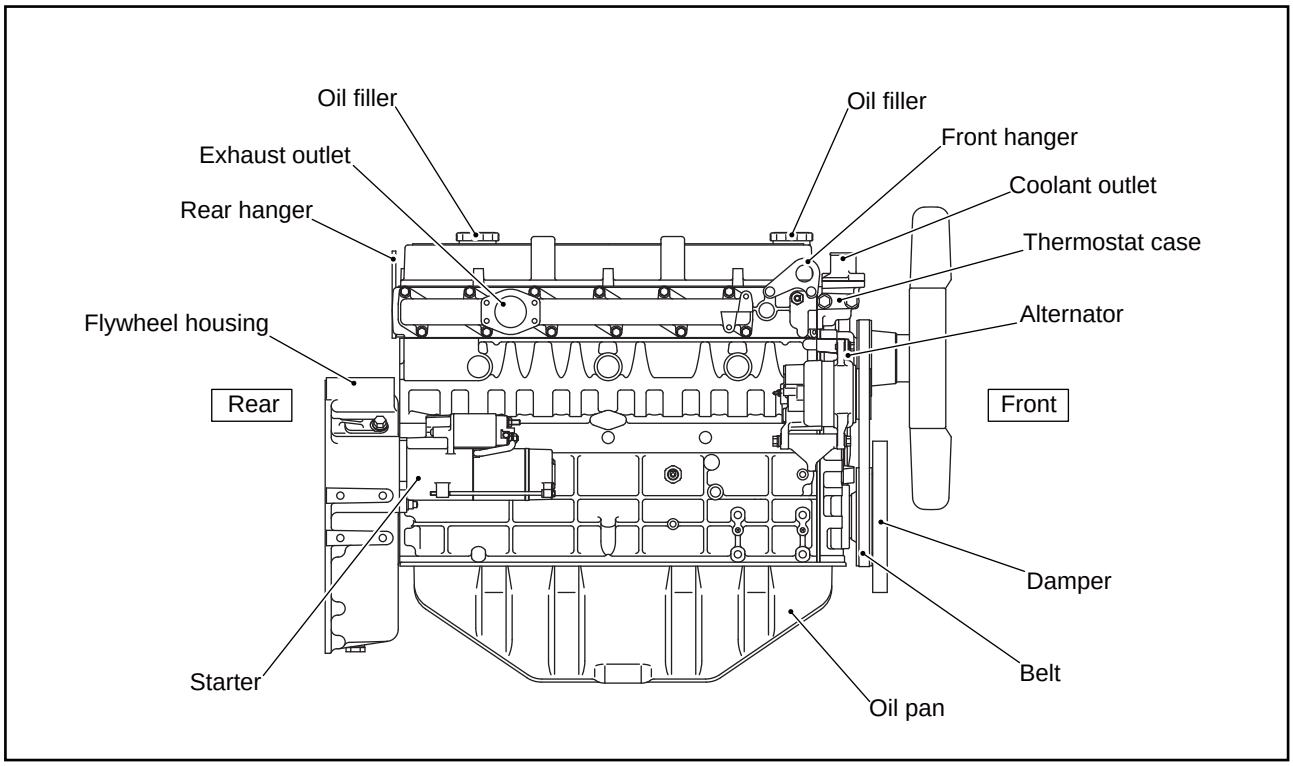


Fig. 2-10 Engine right view

S6S distoributor type fuel injection pump left view

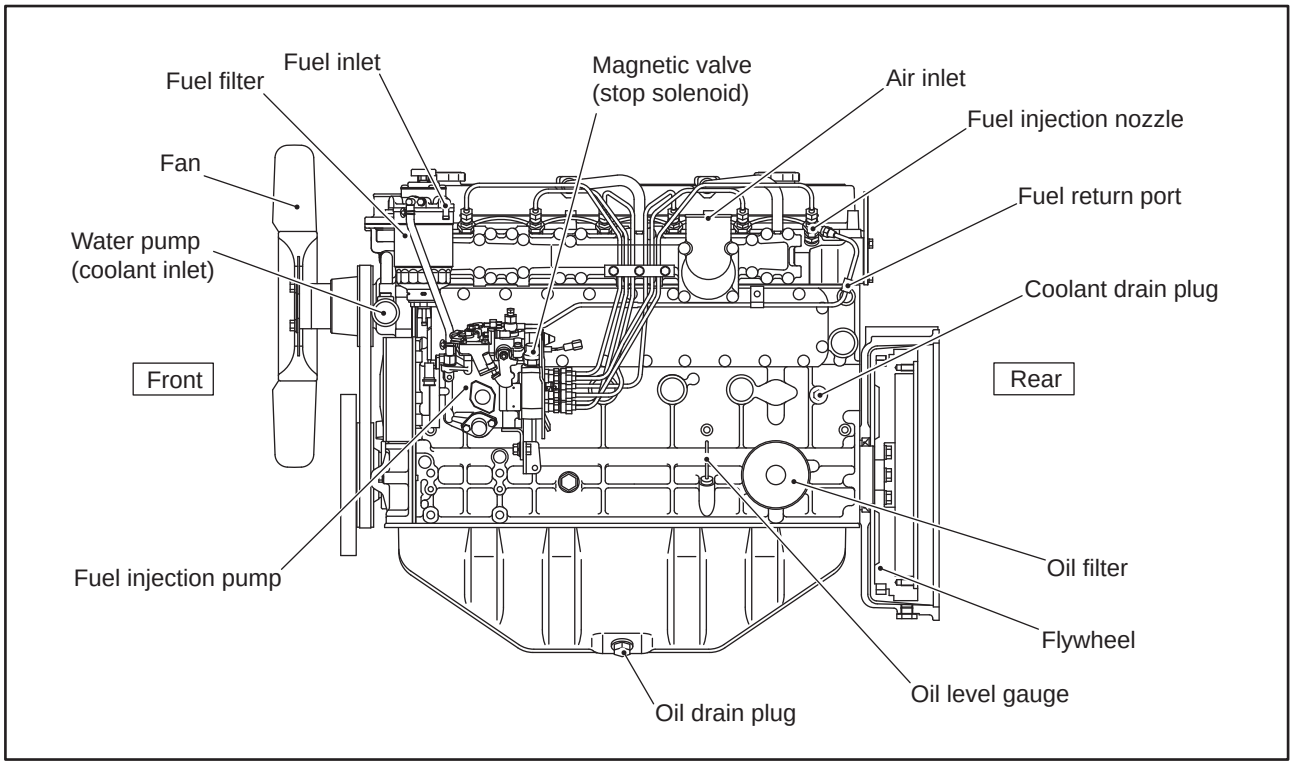


Fig. 2-11 Engine left view

S6S distoributor type fuel injection pump right view

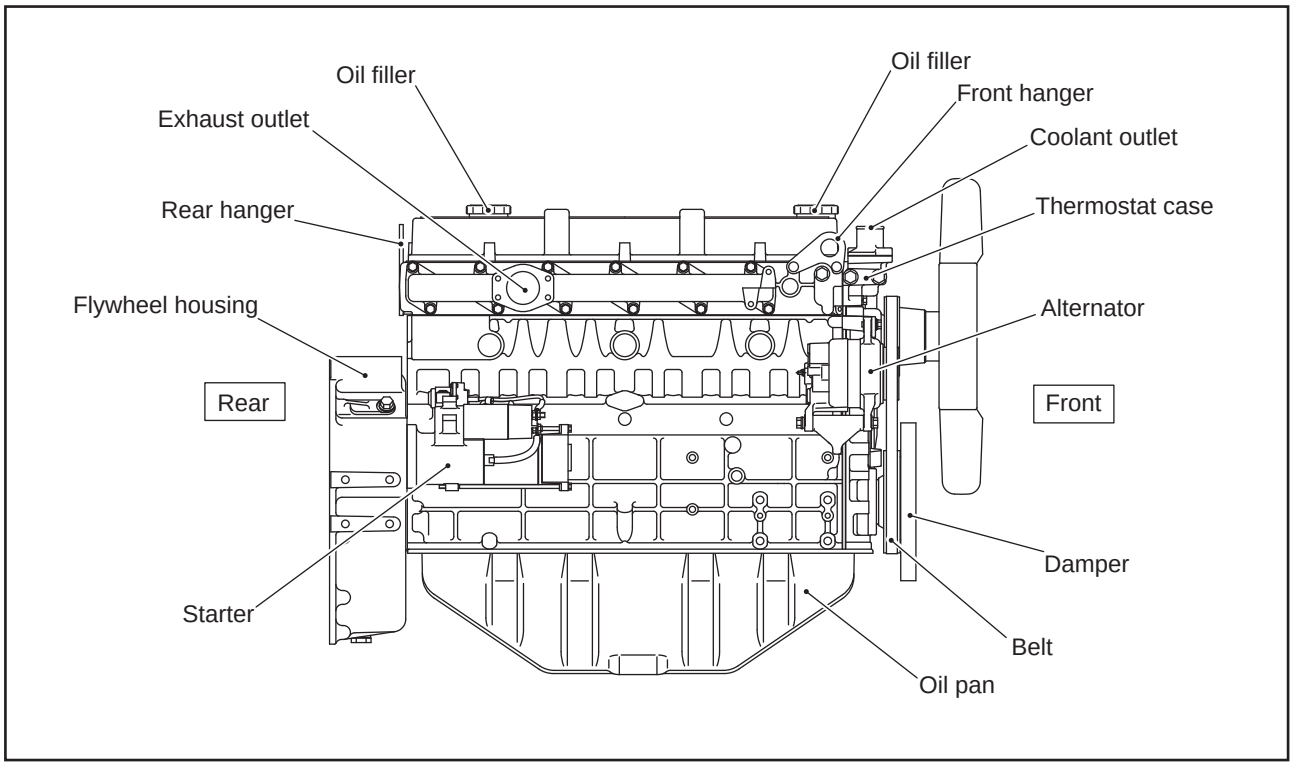


Fig. 2-12 Engine right view

S6S-T distributor type fuel injection pump left view

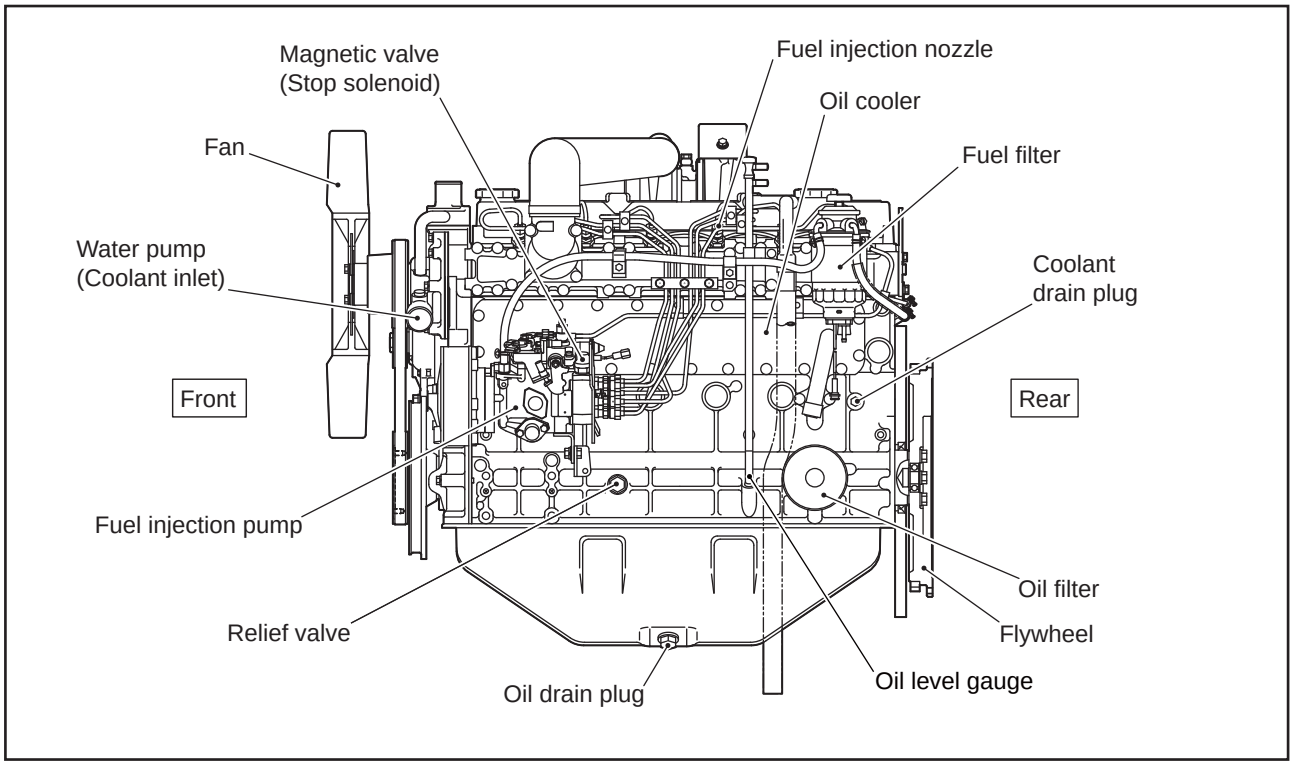


Fig. 2-13 Engine left view

S6S-T distributor type fuel injection pump right view

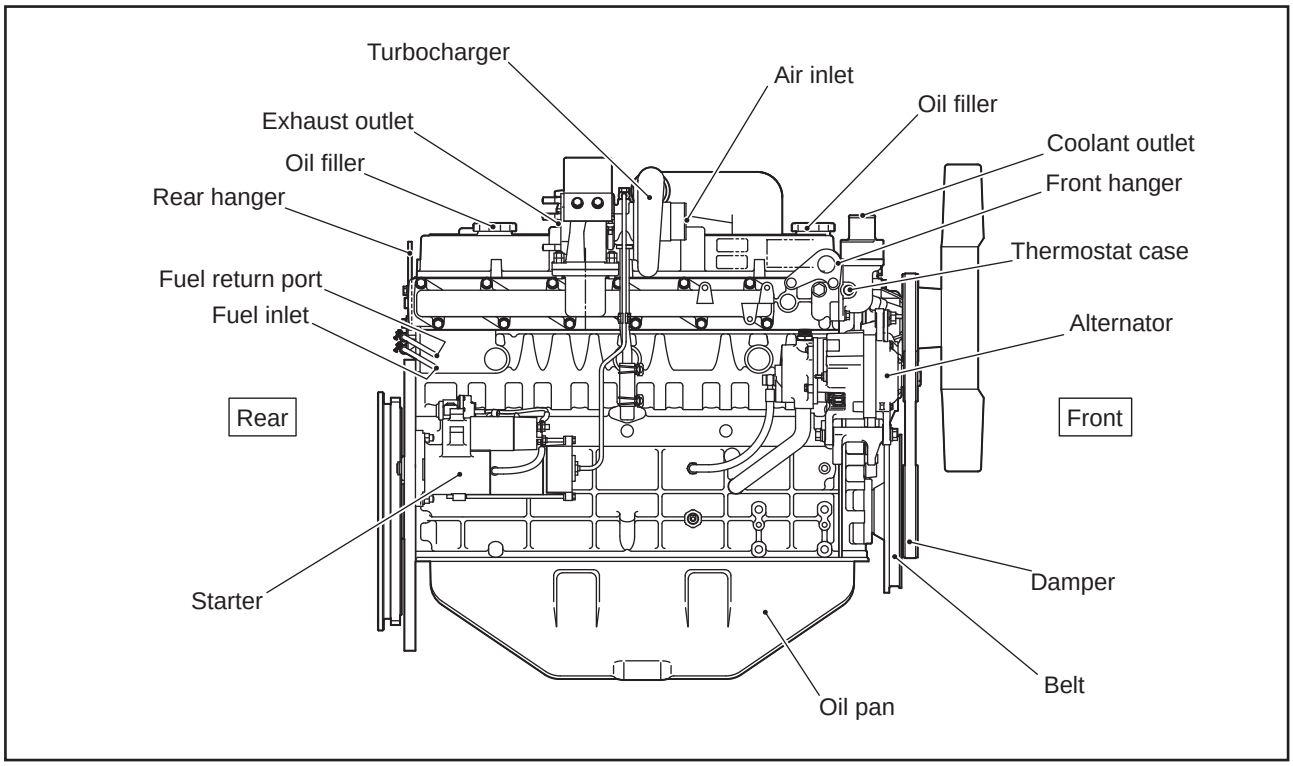


Fig. 2-14 Engine right view

Equipment and instrument

The installed equipment and shapes differ on the engine type.

Starter switch

The starter switch is used to start the engine.

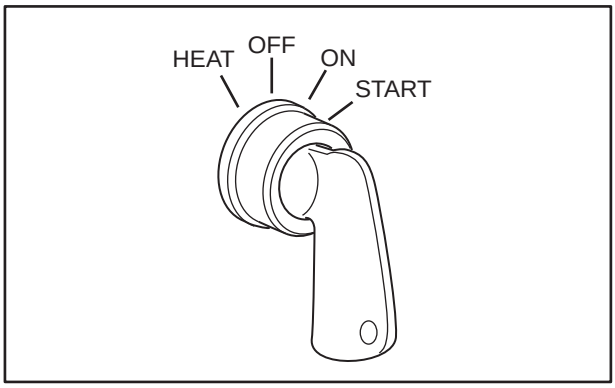


Fig. 2-15 Starter switch

HEAT

When the key is turned to this position, the glow plugs become hot and allow easy startup of a cold engine.

OFF

When the key is turned to this position, power supply to the electric circuits is cut off, and the key can be removed and inserted at this position. To sotp engine, turn the key to this position.

ON

When the key is at this position, power is supplied to the electric circuits. After the engine starts, the key is set to this position.

START

When the key is turned to this position, the starter cranks the engine and the engine starts. When the key is released, ti automatically returns to the "ON" position.

Preheat indicator

The preheat indicator shows the condition of the glow plugs.

As soon as the glow plugs are heated, the preheat indicator turns red.

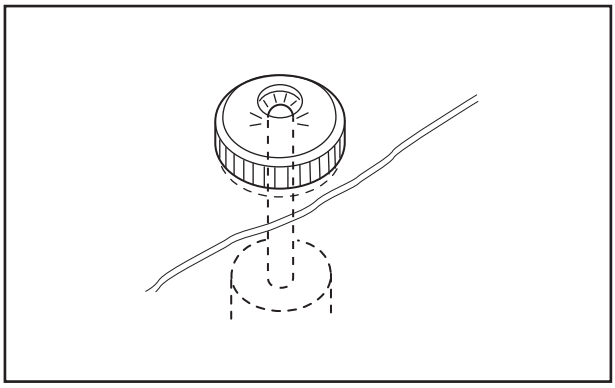


Fig. 2-16 Preheat indicator

Water temperature meter and thermo unit

The engine coolant temperature detected by the thermo unit is displayed by the water temperature meter.
When the water temperature meter shows 95°C [203°F], idle the engine in low gear until the temperature becomes normal. After the temperature becomes normal, perform cooling operation for 5 or 6 minutes and then inspect the cooling system.

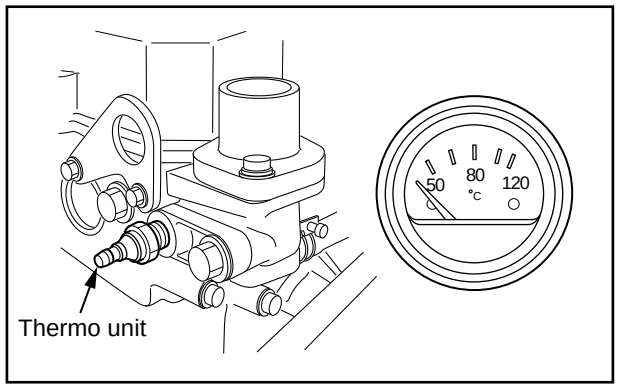


Fig. 2-17 Water temperature meter and thermo unit

Ammeter

It indicates the battery charging condition while the engine is running.
When the battery is charged, the pointer swings to the positive (+) side. When the battery is discharged, the pointer swings negative (-) side.

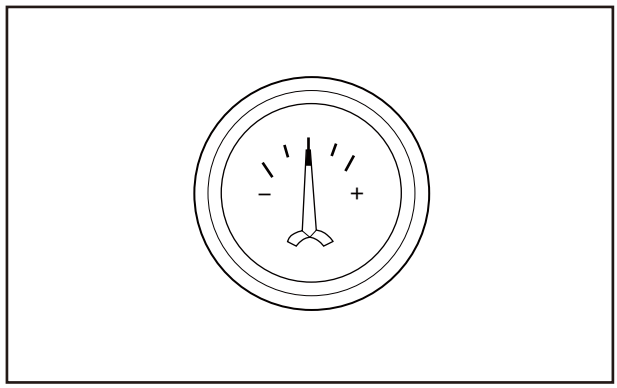


Fig. 2-18 Ammeter

Hour meter

It indicates the operating time of the engine.
When performing the periodic inspection and maintenance, check the time interval with this meter.

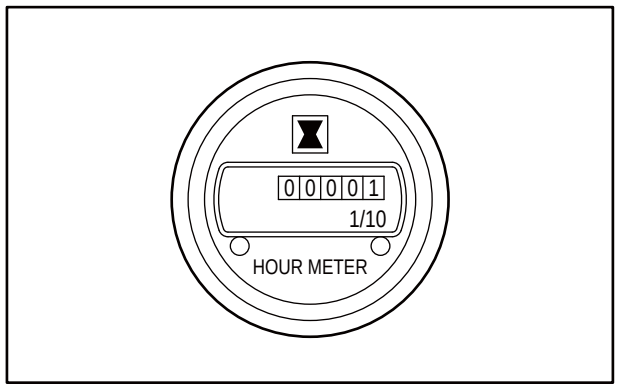


Fig. 2-19 Hour meter

Stop solenoid

The stop solenoid operates for normal shutdown of engine operation.

The stop solenoid moves the rack of fuel injection pump to cut the fuel, and consequently stops the engine.

Two types of stop solenoids are available.

RUN OFF (ETS: Energized To Stop) type

Not energized while the engine is running. Energized by a stop signal to stop the engine.

RUN ON (ETR: Energized To Run) type

Energized while the engine is running, and de-energized to stop the engine.

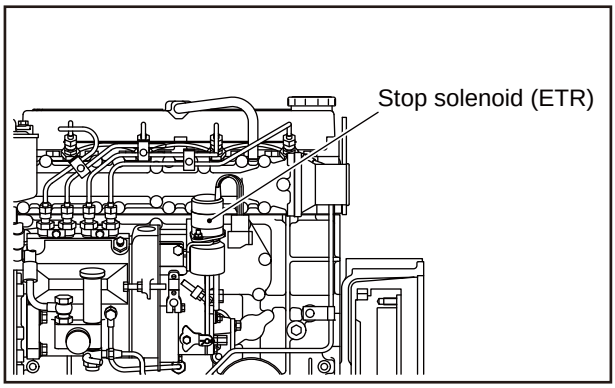


Fig. 2-20 Stop solenoid

Engine protection devices

The engine protection device is a device to prevent the engine from the accident by generating the alarm when abnormality occurs. Stop the engine if the protection device is activated, investigate the cause of abnormality and restore it. When the cause of abnormality is unknown, contact a dealer of Mitsubishi Heavy Industries, Ltd. The installed protection devices, type (set value) or shapes varies according to the specifications.

Oil pressure switch

The oil pressure switch activates the alarm system or stops the engine suddenly when the engine oil pressure becomes abnormally low.

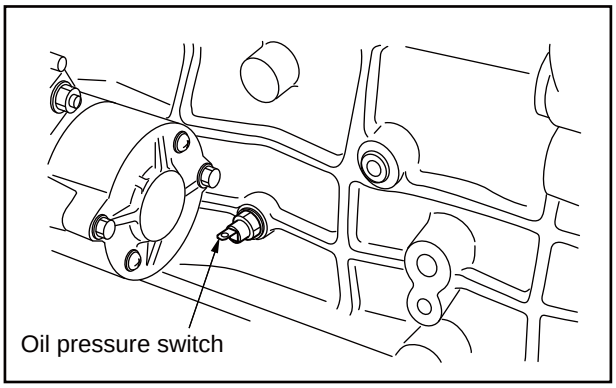


Fig. 2-21 Oil pressure switch

Thermo switch

The oil pressure switch generates an alarm when the engine coolant temperature becomes high and reaches the specified temperature.

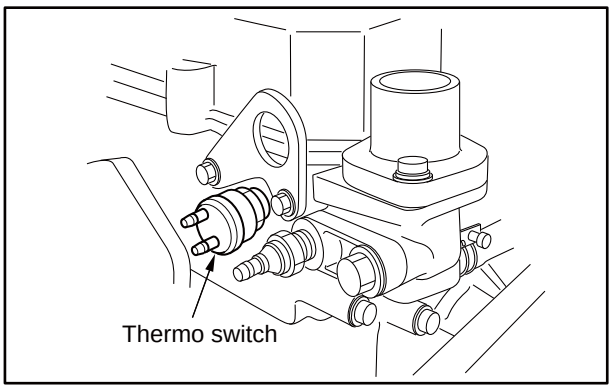


Fig. 2-22 Thermo switch

Air cleaner indicator

The air cleaner indicator alarms with its red signal when air cleaner elements become clogged, the difference in pressure between front air cleaner and rear air cleaner, and reaches the specified value. The signal indicates only, and does not generate an alarm, Therefore, the periodic visually inspection is needed. Press the reset button on the top of air cleaner indicator and restore the signal after cleaned the air cleaner indicator or replaced with a new one.

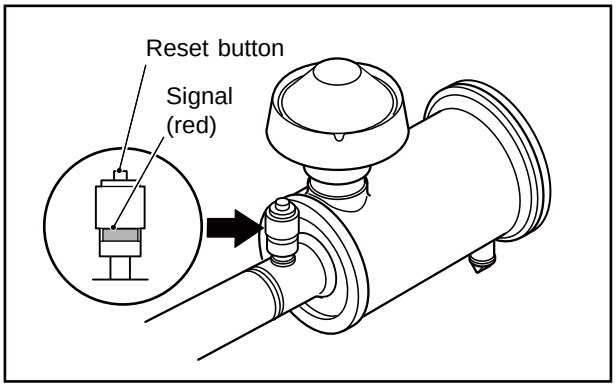


Fig. 2-23 Air cleaner indicator

Chapter 3 OPERATION

Preparations for operation

⚠ CAUTION

Should an engine abnormality be observed during operation, stop the engine and correct the problem, or contact a dealer of Mitsubishi Heavy Industries, Ltd.

Always conduct the following inspection before starting the engine.

Engine external - Inspect

⚠ CAUTION

Be sure to keep combustible materials away from the engine, especially from the hot engine parts such as exhaust manifolds, or the battery. Check for fuel and oil leakage. Clean the top surface of the battery. A fire can be caused by combustible materials placed near hot engine parts. If any abnormality is found, be sure to repair it or contact a dealer of Mitsubishi Heavy Industries, Ltd.

Inspect the engine exterior as described below.

1. Make sure there is no combustible material near the engine or battery. Also, check to make sure that the engine and battery are clean. If combustible materials or dust are found near the engine or battery, remove them.
2. Check the electrical wiring for such components as the starter and alternator for looseness.
3. Check the entire engine for fuel leakage, engine oil or coolant. If leakages are found, repair or contact a dealer of Mitsubishi Heavy Industries, Ltd.
4. Make sure the following valves, plugs and cocks are open or closed (tightened) properly:
   - ♦Fuel feed valve: Open
   - ♦Coolant drain cock (plug): Closed (Tightened)
   - ♦Oil drain valve: Closed

Battery electrolyte level - Inspect

⚠ CAUTION

If battery electrolyte is spilled on your skin or clothes, flush immediately with plenty of water. If battery electrolyte get into your eyes, flush them immediately with plenty of water and then get medical attention.

Do not use open flames or other fire hazards near the battery. When handling the battery, be careful of sparks generated by accidental shorting. For other cautions in handling the battery, refer to "Service battery" (1-6).

Battery electrolyte evaporates during use and the electrolyte level gradually decreases. Proper electrolyte surface level is between the "LOWER LEVEL" and "UPPER LEVEL" lines.

For the battery without level lines, proper electrolyte surface level is about 10 to 15 mm [0.394 to 0.591 in.] above the top of the plates.

If the electrolyte level is low, remove the caps and add distilled water to the proper level.

Note: When adding distilled water, pour in carefully.

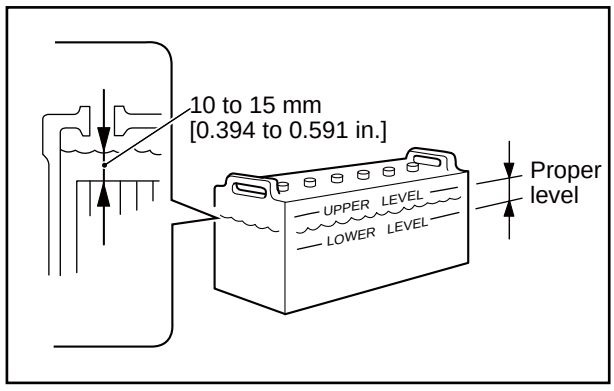


Fig. 3-1 Battery electrolyte level - Inspect

Fuel tank oil level - Check

WARNING

When working around fuel, make sure there are no open flames, heaters or other fire hazards.

Wipe off any spilled fuel completely.Spilled fuel can ignite and cause a fire.

CAUTION

Do not remove the strainer when filling the fuel tank.

For fuel to be used, refer to "FUEL" (4-1).

Make sure the fuel tank is full.

If the fuel level is low, refill the tank to the "FULL" level line.

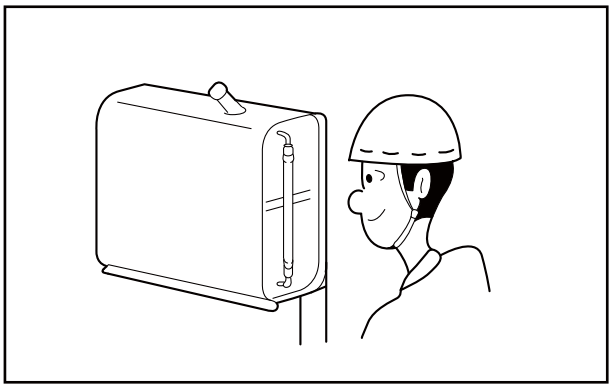


Fig. 3-2 Fuel tank oil level - Check

Engine oil level - Check

CAUTION

For engine oil to be used, refer to "ENGINE OIL" (5-1).

1. Pull out the oil level gauge and wipe it clean using a waste cloth.
2. Insert the oil level gauge fully into the oil level gauge guide, then pull out the gauge again.
3. The proper oil level is between the high and low marks on the oil level gauge. If the oil level is low, add engine oil of the specified type.
4. Install the oil filler cap after refilling.
5. Check the oil pan and other area for oil leakage.

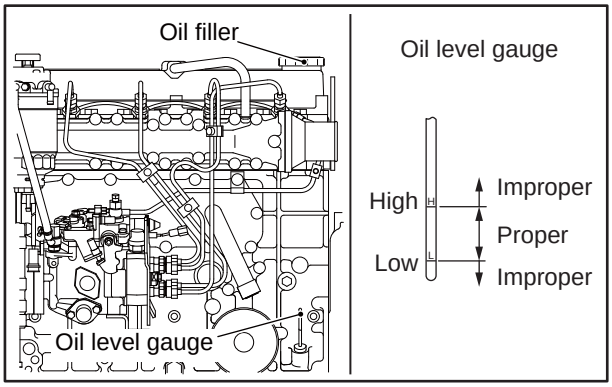


Fig. 3-3 Oil filler and Oil level gauge

Coolant level - Check

⚠ WARNING

Remove the radiator filler cap only after the engine has cooled to room temperature. Place a waste cloth over the cap, and loosen the cap about a half-turn or stand the lever to the upright position to release internal pressure. Never open the radiator filler cap while the engine is hot, otherwise the steam or hot coolant spurts out and you may be scald with it.

1. Open the radiator filler cap and check the coolant level.
2. If the coolant level is low, add coolant to the specified level.

CAUTION

Always use the coolant with the same LLC concentration.

Note: Determine the quantities of LLC based on the coolant capacity and the LLC concentration chart.
For the coolant, refer to "COOLANT" (6-1). For the coolant capacity, refer to "MAIN SPECIFICATIONS" (12-1).

3. If a reserve tank is equipped, fill the reserve tank with coolant up to the "FULL" level line.

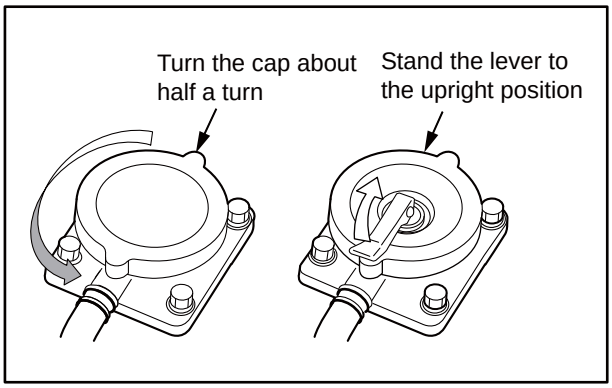


Fig. 3-4 Radiator filler cap

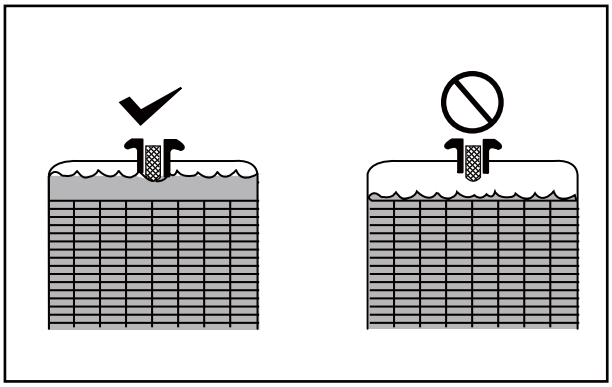


Fig. 3-5 Radiator coolant level

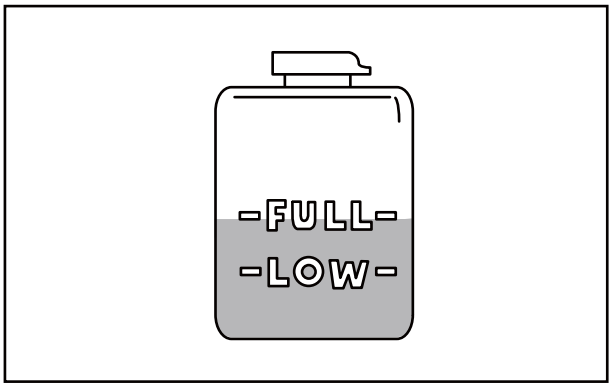


Fig. 3-6 Reserve tank coolant level

Starting

The starting method changes based on the application and specifications.Start the engine according to the specified procedure.

⚠ WARNING

Before starting the engine, check to make sure no one is near the engine and that tools are not left on or near the engine.In a loud voice, notify people in the area when starting the engine.

CAUTION

Do not apply a load to the engine at starting. (Disengage the clutch if installed.)

Continuous operation of the starter will drain the battery power and cause the starter to seize. Do not use the starter for more than 10 seconds at a time. When the engine does not start, wait for more than one minute before cranking again.

Warm up operation

⚠ WARNING

Do not approach rotating parts during operation. Entanglement by rotating parts can cause serious injury.

After the engine starts, operate the engine in a no load condition at low idling speed for 5 to 10 minutes to warm up the engine.

Checking engine oil pressure

During warm up operation, check if the oil pressure is in the range of standard value (0.15 MPa {1.5 kgf/cm^2} [21 psi] or more).

Also, make sure the oil pressure gauge is operating properly.

Note: The oil pressure gauge may indicate a higher level than normal level immediately after the engine starts, due to the low oil temperature. The pressure gradually lowers to the normal level as the oil temperature rises.

External inspection during warm up

Visually check the external view of the engine for fuel, engine oil and coolant leakage, or exhaust gas leakage from joints.

Operation

Cautions when operating

⚠ WARNING

Do not approach rotating parts during operation. Entanglement by rotating parts can cause serious injury.

⚠ CAUTION

Do not touch any hot part of the engine such as exhaust pipes during operation or immediately after shut down. A hot engine can cause burns.

CAUTION

Always provide adequate ventilation in the engine room. If air supply to the engine room is not sufficient, the room temperature rises and can affect engine output and performance.

For the first 50 hours, operate the engine under a light load for break-in operation. Operating the engine under heavy load or severe conditions during the break-in period can shorten the service life of the engine.

Do not turn the battery switch to "OFF" position when the engine is running. Turning off the battery switch during operation not only stops the instrument operations but also may deteriorate the alternator diode and regulator.

Never turn the key to the "START" position during operation. The starter may be damaged.

When operating the engine with a 30 % of rated load or lower, limit each operation to an hour. Prolonged warm up operation causes carbon build-up in the cylinders that leads to incomplete combustion. Operate the engine with a 30 % of rated load or more for over 5 minutes after continuous operation for an hour to prevent causing carbon build-up.

Inspection during operation

Carefully check the exterior of engine such as piping joints for leaks.

Check for abnormal engine noises or vibrations such as knocking.

Check the color of exhaust gas from the exhaust muffler.

Check the instruments and gauges for proper operation and make sure they indicates normal values.

Table 3-1 Standard values at rated speed

Item	Standard
Engine oil pressure	0.29 to 0.49 MPa {3 to 5 kgf/cm^2} [43 to 71 psi]
Coolant temperature	70 to 90°C [158 to 194°F]

Note: (a) When the oil pressure drops below 0.15 MPa {1.5 kgf/cm^2} [21 psi] in normal operation, or below 0.05 MPa {0.5 kgf/cm^2} [7 psi] at low idling, stop the engine immediately.
Be sure to locate the cause of problem and correct it before restarting the engine.

(b) When the thermo switch is activated in normal run, idle the engine in low gear immediately until the engine temperature becomes normal. Then, perform cooling operation for 5 or 6 minutes before stopping the engine.Be sure to locate the cause of problem and correct it before restarting the engine.

Stopping

⚠ CAUTION

Stopping the engine abruptly while engine parts are hot due to high-speed operation can be a cause for heat up of the engine parts and shorten the engine life. Before stopping the engine, idle the engine in low gear immediately until the engine temperature becomes normal except in an emergency. Then, perform cooling operation for 5 or 6 minutes before stopping the engine and inspect the whole engine.
Never accelerate the engine immediately before shutting it down.
Do not restart the engine immediately after abnormal shut down. When the engine stops with alarms, be sure to locate the cause of the problem and correct the problem before restarting the engine. After restarting the operation, inspect the whole engine for any abnormalities again. If the engine has an abnormality, repair it immediately.

Engine stopping method may differ depending on the specifications.
Follow the instructions according to the specifications of the equipment.

Inspection after stopping

Inspect the engine for fuel, oil or coolant leakage. If any leakage is found, repair the leakage or contact a dealer of Mitsubishi Heavy Industries, Ltd.

Chapter 4 FUEL

Recommended fuel

WARNING

Use a fuel specified in this manual only. Do not refill the fuel tank more than the specified level, as it may result in a fire.

Use a diesel fuel equivalent for "JIS K 2204 diasel fuel".

It is necessary to use a fuel that has a pour point suitable for the ambient temperature.

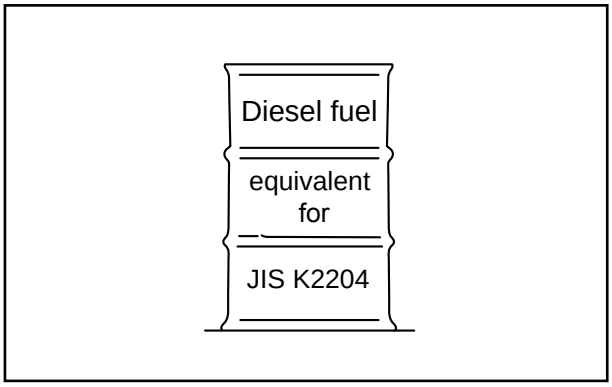


Fig. 4-1 Recommended fuel

Handling fuel

When using fuel stored in a storage tank, leave it to sit for more than 24 hours so that dust and water can settle at the bottom. Then, use the upper clean fuel.

Fill up the fuel tank or service tank after each operation.

This prevents water from mixing with fuel in the tank and also gives time for dust and water to separate and settle at the bottom of the tank.

Before refilling, clean the areas around the caps thoroughly and remove the caps from the drum and tank. Also clean your hands and the hose before refueling. When using a hand-operated pump, be careful not to pump water or sediment accumulated at the bottom of the storage tank.

Be sure to use a strainer when filling fuel tank. For a complete filtration, it is recommended to use a clean lint-free cloth together with the strainer.

Table 4-1 Recommended limit and use limit of fuel property

Properties		Recommended limits	Use limits	Test method
Flash point		50°C [122°F] or higher	45°C [113°F]	JIS K 2265:2007 ISO 3769 ISO 2719
Distillation	Initial boiling point	170°C [338°F] or higher		JIS K 2254:1998 ISO 3405
	90 % distillate temperature	330 to 380°C [626 to 716°F]		
Pour point (PP)		6°C [42.8°F] or lower than ambient temperature		JIS K 2269:1987 ISO 3016
Cloud point (CP)		Below ambient temperature		JIS K 2269:1987 ISO 3015
Cold filter plugging point (CFPP)		3 °C [37.4 °F] or lower than ambient temperature		JIS K 2288:2000 IP 309/96
Carbon residue (10 % bottom oil)		0.1 weight % or lower	0.4 weight % or lower	JIS K 2270:2000 ISO 6615 ISO 10370
Cetane number		45 or higher	40 or higher	JIS K 2280:1996 ISO 5165
Cetane index (new type)		45 or higher	40 or higher	JIS K 2280:1996 ISO/DIS 4264
Kinematic viscosity		2.0 mm^2/s [0.0031 in^2/s] or more at 30 °C [86 °F] 8.0 mm^2/s [0.0124 in^2/s] or more at 30 °C [86 °F]		JIS K 2283:2000 ISO 3104
Sulfur content		0.2 weight % or lower (Except in cases the value is specified by the emission control.)		JIS K 2541:2003 (The content should be as low as the diesel fuel.) ISO 4260 ISO 8754
Water content and sediment		0.1 volume % or lower		JIS K 2275:1996 ISO 3733
Ash content		0.01 % by mass or less	0.03 weight % or lower	JIS K 2272:1998 ISO 6245
Copper corrosion (3 hrs at 50 °C [122 °F])		Color change = Copper plate No.3 or less		JIS K 2513:2000 ISO 2160
Density at 15 °C [59 °F]		0.83 to 0.87 g/cm^3 [49.9424 to 54.3123 lb/ft^3]	0.80 to 0.87 g/cm^3 [49.9424 to 54.3123 lb/ft^3]	JIS K 2249:1995 ISO 3675
Caulking	24 hrs at 250 °C [482 °F]	75 % carbonization or less	80 % carbonization or less	Fed 791B
	24 hrs at 230 °C [446 °F]	55 % carbonization or less	-	
	48 hrs at 180 °C [356 °F]	Tar-free	-	
Aromatics substances (by HPLC)		35 % by volume or less (total of aromatic components)		JIS K 2536:2003 ISO 3837
Polycyclic aromatic content		8 % by volume or less		JIS K 2536:2003 IP 391
Asphaltene		0.1 weight % or lower		-

Table 4-1 Recommended limit and use limit of fuel property

Properties	Recommended limits	Use limits	Test method
Foreign materials (foreign materials at engine fuel inlet)	5.0 mg/liter or less		JIS B 9931:2000 ISO 4405
Lubricity: MWSD (Measured mean Wear Scar Diameter) by HFRR wear test at 60 °C [140 °F] fuel temperature	460 µm [0.02 in.] or less (calculated wear scar diameter at WS 1.4 kPa {0.0143 kgf/cm^2} [0.2031 psi])		ISO 12156-1
BDF: Biodiesel fuel (FAME: Fatty Acid Methyl Ester)	BDF quality shall meet JIS K 2390, EN14214, or ASTM D6751 BDF blending of 5 % by volume or less is approved (Except in cases the value is specified by the emission control.)		JIS K 2390:2008 (FAME for mixture) ASTM D 6751 EN 14214

Note: When using fuel less than use limits, white smoke, worsening start up or unstable rotation may occur.

Chapter 5 ENGINE OIL

Recommended engine oil

CAUTION

Use only the engine oils recommended in this manual. Never use other oils.
The use of inappropriate or inferior oils will result in sticking of piston rings, seizure between piston and cylinder, or premature wear of bearings and moving parts, and significantly shortens the service life of the engine.

Many oil standards, which are established through special engine tests, are available to determine the quality of oil depending on the engines to which they will be applied and on operating conditions. Among those standards, API (American Petroleum Institute) service classifications are mostly used to classify engine oils. SAE specifies the viscosity only, while the API service classification indicates the quality level of engine oil.
For engine lubrication oil, please use API service classification CF.

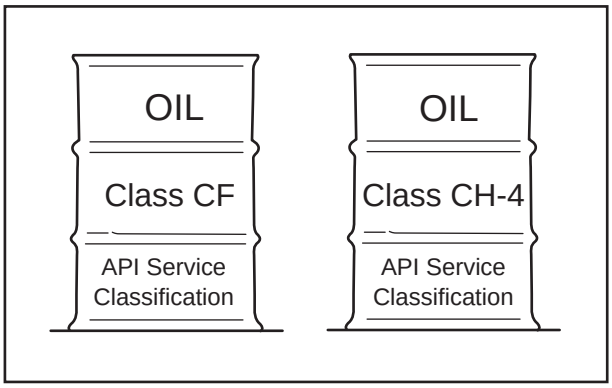


Fig. 5-1 Recommended engine oil

Selection of oil viscosity

Use the following chart to select the appropriate oil viscosity according to the ambient temperature.
Excessively high oil viscosity causes power loss and an abnormal rise of oil temperature, while excessively low oil viscosity accelerates wear due to inadequate lubrication, and also causes a decrease in engine output due to leakage of combustion gas.

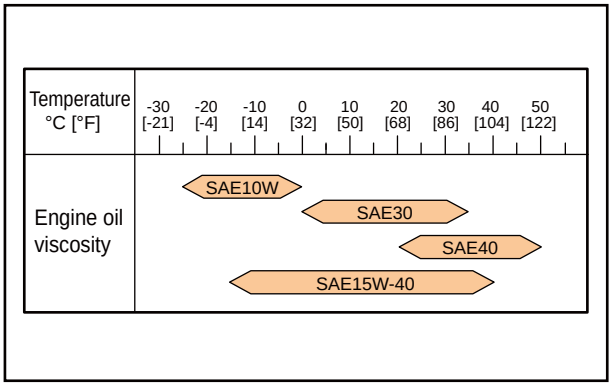


Fig. 5-2 Selection of oil viscosity

Handling engine oil

WARNING

Before filling the engine with engine oil, stop the engine and make sure there are no open flames and other fire hazards near the engine. Leaked or spilled oil on hot surfaces or electrical components can cause a fire. Wipe off any spilled oil immediately and thoroughly. After filling, securely close the filler cap.

CAUTION

Never mix different brands of engine oil. Mixing different brands of engine oil may cause a chemical reaction of additives in the engine oil that could degrade the engine oil quality.

When handling oil in greater than the legally specified quantities, be sure to have the work performed by a service station in compliance with the law. When removing oil from the engine or oil can, use an oil pump. Do not suck oil with the mouth to siphon it.
Be sure to close the cap on the oil can after use.
Keep oil in a well-ventilated area and out of direct sunlight.
Be sure to obtain the MSDS of the engine oil used and follow the instructions of the MSDS.

Engine oil performance requirements

Engine oil requires the following performances.

- Excellent dispersion performance (the ability of oil to disperse sludge in the oil) at high temperature that prevents engine oil deterioration due to sludge accumulation and soot contamination.
- Excellent acid-neutralizing performance that prevents oxidative degradation due to fuel sulfur content.
- Excellent high temperature oxidation stability that endures continuous operation under prolonged high-load.
- Sufficient viscosity concentration to maintain the cold start performance, and lubrication performance at high temperature.
- Good rust and corrosion resistance to water.
- Good foam resistance to prevent the lubricating quality from lowering due to oxidation.

Engine oil deterioration mechanisms

- Engine oil deteriorates due to natural deterioration and due to the contamination. The natural deterioration of oil has two primary causes; one is the degradation caused by oxidation reaction or thermo decomposition of base oil and additives, and the other is the degradation in the performance due to consumption of additives during use.
- Contaminants such as fuel and combustion products (soot, water vapor or oxidation products) that intrude into oil have critical influence on oil quality. Soot adheres to the oil film of cylinder wall, and is scraped off the cylinder wall by the piston ring. Such soot increases the rate of insoluble substances in the engine oil and can cause the wear of piston rings and cylinder walls.
- Abrasion powder in the engine oil also accelerates deterioration as it can catalyze oxidation reaction. Dust and dirt entered from outside deteriorate the engine oil as well. Contamination and deterioration process accelerates with operation time.
- Deterioration products and contaminants in the engine oil, if it is a small amount, are harmless as they can be dispersed in oil. However, if it is a large amount, they become harmful. Since such products and contaminants flow out of the oil pan and start to accumulate inside the piston and in the oil system, they eventually lead to serious problems such as piston ring sticking and bearing scuffing.
- Sulfur content in fuel is burned and transformed into sulfurous acid gas and sulfuric gas that cause corrosive wear of cylinders and piston rings. A detergent additive in the engine oil neutralizes them into harmless substances. As the detergent additive is consumed in its role of neutralizing, the engine oil total base value decreases. A decrease in the total base value indicates a corresponding decrease in soot dispersion ability. As a result, deposits on the pistons increase.
- Due to oxygen in the air, oil temperature rise under high-load continuous operation causes oxidation degradation. As oxidation degradation accelerates, oxidative products are polymerized. The polymerized oxidative products cause the oil viscosity to increase, which leads to the generation of sludge and varnish. As a result, problems such as lubrication failure and piston ring sticking occur. Also acid substances generated by oxidation can cause problems like main bearing corrosion.

Definition of properties of engine oil

Viscosity

Viscosity is a basic physical property of engine oil and is considered as the most important aspect when evaluating oil.

Contamination of oil by blow-by gas and deterioration of oil by its natural aging in crease the viscosity and degrade the performance of viscosity, which will cause the deposition of sludge inside the engine and oil filter clogging. Contamination of oil by fuel and sheared molecules of viscosity index improver in oil decrease the viscosity and degrade the performance of viscosity, which will cause insufficient lubrication and friction/wear of engine parts.

Total base number

Total base number (TBN) shows the ability to neutralize acids such as organic acid due to engine oil oxidation, or sulfurous or sulfuric acid due to the sulfur content of fuel.

Because TBN indicates the amount of dispersant detergent in oil, it can be used to estimate consumption of basic dispersant detergent. The ability to disperse sludge declines as dispersant detergent is used up.

Total acid number

The total acid number in oil increases as the organic acid is being derived by the engine oil oxidation, or sulfurous acid or sulfuric acid derived by the combustion of sulfur content of fuel, or the oil becomes contaminated with imperfect combustion products.

An increase in the total acid number will result in corrosion or wear of the inner parts of the engine (such as cylinder liners or metal) due to sulfur content, and piston ring seizure due to sludge.

Water content

Water in oil promotes corrosion/wear, and decreases lubricity in sliding parts.

Flash point

The flash point is lowered by contamination with fuels. Flash point is measured to check the dilution of fuel. The dilution of fuel reduces oil film, and causes insufficient lubrication that will cause friction or wear of engine parts.

Insoluble

Insoluble includes acid products of engine oil, imperfect combustion products, sludge or soot, metal abrasive particles and dust. Insoluble is an indication of degradation/contamination of oil.

Dispersant detergent, which is an additive in engine oil, absorbs sludge particles, and disperses them as fine particles in oil. Total insoluble density and remaining dispersibility can be obtained by measuring insoluble and coagulated insoluble (using chemical specialities to stop action of disperse detergent and to collect the sludge dispersed in oil) by which piston ring seizure or premature wear can be prevented before it occurs.

Service Limits of engine oil

Engine oil degrades through the use and by lapse of time.

To determine the timing of engine oil replacement, analyze the used oil, and understand the condition of oil deterioration and oil defacement. It is also required to compare the oil analysis results and the engine analysis results including inside contamination and wear condition of engine, and to consider the engine operating condition.

The engine oil affects the engine oil quality to use, the engine operating condition and the quality of fuel.Analyze the used oil, and understand the condition of oil deterioration and oil defacement. To determine the timing of engine oil replacement, the stabiration of engine is required.

Refer to the following table for the determination of engine oil performance degradation. If any of the following deviate the limit, replace the engine oil with new oil.

Table 5-1 Engine oil properties

Properties		Standard	Test method
Viscosity	mm^2/s [in^2/s] @100°C [212 °F]	+30% or less -15% or more of new oil	JIS K 2283:2007 ISO 3107 ISO 2909
Total base number	mgKOH/g	2.0 or more with hydrochloric acid (HCL) method 1/2 of new oil or more with perchloric acid (PCA) method	JIS K 2501:2003 ISO 3771
Total acid number	mgKOH/g	Up to +3.0 of new oil	JIS K 2501:2003 ISO 3771
Water content	Vol %	0.2 or less	JIS K 2275:1996 ISO 9029
Flash point (open cup)	°C [°F]	180 [356] or higher	JIS K 2265:2007 ISO 3769 ISO 2719
Pentane insoluble	Wt %	0.5 or less	ASTM D 893
Pentane insoluble coagulated	Wt %	3.0 or less	ASTM D 893

Chapter 6 COOLANT

Note: In this operation manual, the word "coolant" represents the liquid combined water and LLC.

Recommended water for coolant

Use soft water for the engine cooling system. The water quality must meet the requirements in the Table below. Basically, the water quality should be within the recommended value, however, up to the limit is acceptable.

Table 6-1 Water quality standards

Item	Chemical symbol	Unit	Recommend value	Limit	Main adverse effect
pH (25 °C [77 °F])	-	-	6.5 to 8.0	6.5 to 8.5	Corrosion and rust, scale formation
Electrical conductivity (25 °C [77 °F])	-	mS/m	< 25	< 40	Corrosion and rust, scale formation
Total hardness	$CaCO_3$	ppm	< 95	< 100	Scale formation
M alkalinity	$CaCO_3$	ppm	< 70	< 150	Scale formation
Chlorine ion	Cl^-	ppm	< 100	< 100	Corrosion and rust
Sulfuric acid ion	SO_4^{2-}	ppm	< 50	< 100	Corrosion and rust
Total iron	Fe	ppm	< 1.0	< 1.0	Scale formation
Silica	SiO_2	ppm	< 30	< 50	Scale formation
Residue from evaporation	-	ppm	< 250	< 400	Scale formation

Note: Figures in parentheses are the standard value. In addition to the items specified above, turbidity is specified to be below 15 mg/liter.

Long life coolant (LLC)

⚠ CAUTION

Should coolant or LLC be accidentally consumed, induce vomiting immediately and seek medical attention. If LLC should enter eyes, flush immediately with plenty of water and seek medical attention.

Be sure to use Mitsubishi Heavy Industries, Ltd. genuine long life coolant (LLC) "GLASSY long life coolant (Ethylene glycol type)" or "PG GLASSY long life coolant (Non-amine type)" as coolant. When using other brand LLCs by necessity, be sure to use the LLC that meets the specification in Mitsubishi Heavy Industries, Ltd. Mitsubishi heavy industries, Ltd. disclaim the warranty claim concerning malfunctions caused by the use of LLC that does not meet the following specification.

Genuine LLC

Mitsubishi Heavy Industries, Ltd. recommends the use of our genuine long life coolant "GLASSY long life coolant (Ethylene glycol type)", and Eco-friendly product "PG GLASSY long life coolant (Non-amine type)", which are most appropriate coolant for diesel engine from Mitsubishi Heavy Industries, Ltd.

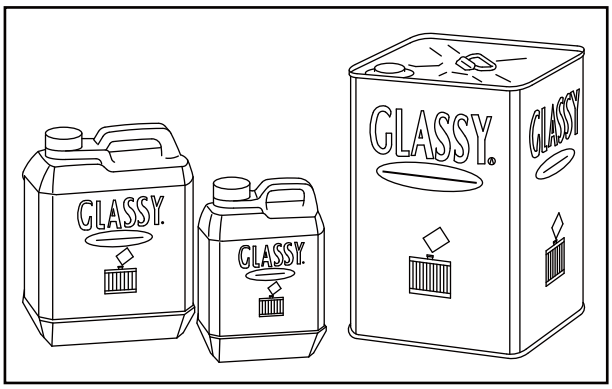


Fig. 6-1 GLASSY - LLC

Other brand LLCs

CAUTION

Never mix Mitsubishi Heavy Industries, Ltd. genuine LLC with other brand LLCs. Mixing with other brand LLCs degrades the performance of Mitsubishi Heavy Industries, Ltd. genuine LLC.

When using LLC other than Mitsubishi Heavy Industries, Ltd. genuine long life coolant (LLC) "GLASSY long life coolant (Ethylene glycol type)" or "PG GLASSY long life coolant (Non-amine type)", be sure to use the LLC which meets specification in Mitsubishi Heavy Industries, Ltd.

The quality and performance of commercially available LLCs as well as their component variations are the responsibility of LLC suppliers.

Before purchasing commercial LLC, be sure to discuss the suitability of LLC with the LLC supplier.

Use only all-season LLC (non-amine type). Do not use antifreeze alone instead of LLC.

Standard for other brand LLC

When using other brand LLCs by necessity, be sure to use the LLC that meets following specification. Mitsubishi heavy industries, Ltd. disclaim the warranty claim concerning malfunctions caused by the use of LLC that does not meet the following specification.

General demands of LLC

- LLC shall be a homogeneous liquid.
- Engine cooling system shall not receive troubles such as corrosions and precipitation products etc. by LLC when the LLC is diluted to 30 to 60 % density.
- LLC shall be mixed with other LLC that satisfies this specification, and shall not separate elements each other, and shall not decrease the performance each other.
- LLC shall not allow the container to be corroded, and shall not has precipitation products etc. even if LLC is left in the container for 6 months.
- LLC shall not has extraction products etc. even if LLC is kept in -20 to -25°C [-4 to -13°F]
- The validity term of the quality that provides with this specification is 2 years after it delivers with the indoor normal temperature keeping.

LLC specification

LLC shall examine according to JIS K2234 section 7 (examination methods), and satisfy this specification. General matters and the sample to the examination is shown in JIS K2234.

Table 6-2 LLC specification

Property				Standard
External				Not precipitation
Density				Minimum 1.112 g/cm^3 [69.4199 lb/ft^3] (20/20 °C) [68/68 °F] (Stock solution)
Water content				Maximum 5.0 weight % (Stock solution)
Frozen temperature		30 vol %		Maximum -14.5 °C [6 °F]
		50 vol %		Maximum -34.0 °C [-29 °F]
Boiling temperature				Minimum 155 °C [311 °F] (Stock solution)
pH				7.0 to 11.0 (30 vol %)
Bubbling character (ASTM D 3306-01)		30 vol %		Maximum 4.0 ml
		33$_{1/3}$ vol %		Maximum 150 ml, Disappearance of bubble within 5 sec.
Hard water adaptability				Maximum 1.0 (50 vol %)
Metallic causticity (88±2°C [190±36°F], 336±2 Hr, 30 vol % (E.G), 50 vol % (P.G))	Test piece	Mass change	Aluminum	±0.30 mg/cm^2
			Cast iron	±0.15 mg/cm^2
			Steel	±0.15 mg/cm^2
			Brass	±0.15 mg/cm^2
			Solder	±0.30 mg/cm^2
			Copper	±0.15 mg/cm^2
		External of test piece after the examination		Not corrosion on surface excluding between test piece and spacer. Discoloration is OK.
	Bubbling while examination			Not bubbling overflow
	Properties of liquid after the examination	pH		6.5 to 11.0
		pH change		±1.0
		Precipitation		Maximum 0.5 vol %
		External of liquid		Not remarkable discoloration, separation and gel.
Circulation metallic causticity (98±2°C [208±36°F], 1000 Hr, 30 vol % (E.G), 50 vol % (P.G))	Test piece	Mass change	Aluminum, Cast iron, Steel, Brass, Solder, Copper	±0.30 mg/cm^2
		External of test piece after the examination		Not corrosion on surface excluding between test piece and spacer. Discoloration is OK.
	Properties of liquid after the examination	pH		7.0 to 9.0
		pH change		±1.0
		Pre-alkalinity change		±15 %
		Precipitation		1.0 vol %
		External of liquid		Not remarkable discoloration, separation and gel.
		Density of ion	Fe, Cu, Al, Zn, Pb, NH_4^+	Maximum 10 ppm

Table 6-2 LLC specification

Property				Standard
Circulation metallic causticity (88±3°C [190±37°F], 1000±2 Hr, 30 vol % (E.G))	Test piece	Mass change	Aluminum	±0.60 mg/cm^2
			Cast iron	±0.30 mg/cm^2
			Steel	±0.30 mg/cm^2
			Brass	±0.30 mg/cm^2
			Solder	±0.60 mg/cm^2
			Copper	±0.30 mg/cm^2
		External of test piece after the examination		Not corrosion on surface excluding between test piece and spacer. Discoloration is OK.
	Properties of liquid after the examination	pH		6.5 to 11.0
		pH change		Maximum ±1.0
		External of liquid		Not remarkable discoloration, separation and gel.
	Condition of parts	Pump seal		Not trouble while the examination
		Inside of pump case and blade		Not remarkable corrosion
Rubber adaptability (30 vol %, 115°C [239°F], 360 Hr)	Silicon	Tensile strength change		-60 to 0 %
		Elongation change		-40 to +20 %
		Volume change		0 to +40 %
		Hardness change		-20 to +10 %
	Acrylonitrile butadiene rubber	Tensile strength change		0 to +10 %
		Elongation change		-15 to +15 %
		Volume change		0 to +40 %
		Hardness change		-10 to 0 %
	Ethylene propylene diene monomer	Tensile strength change		0 to +10 %
		Elongation change		-30 to 0 %
		Volume change		0 to +10 %
		Hardness change		-10 to 0 %
Storage stability vol % (30 vol %, room temperature, 6 Hr)				Maximum 0.3

Maintenance of LLC

⚠ CAUTION

Should coolant or LLC be accidentally consumed, induce vomiting immediately and seek medical attention. If LLC should enter eyes, flush immediately with plenty of water and seek medical attention.
LLC is toxic. Never dispose of coolant containing LLC drained from engine into regular sewage. For disposal of used coolant, consult LLC distributor.

Replacement intervals of LLC

CAUTION

Be sure to renew LLC at the intervals specified in the maintenance schedule of this manual.
Failure to renew LLC may cause malfunctions due to performance degradation of preventing rust and cavitation.

The coolant mixed with LLC which Mitsubishi Heavy Industries, Ltd. recommended expires in 2 years. Be sure to change coolant at least once every 2 years.

LLC concentration

Keep the LLC concentration of 30 % (GLASSY) and 40 % (PG GLASSY) on any temperature conditions. LLC of less than 30 % concentration does not provide sufficient corrosion protection. If the LLC concentration is lower than 10 %, it may accelerate corrosion.
When adding coolant, do not add plain water. Always use coolant with the same LLC concentration.

Table 6-3 Recommended LLC concentration

Item	Type	External	Lowest ambient temperature			
			-10 °C [14 °F] or above	-20 °C [-4 °F] or above	-30 °C [-22 °F] or above	-45 °C [-40 °F] or above
LLC concentration (%)	GLASSY	Green	30	40	50	60
	PG GLASSY	Red	40	55	70	-

Note: (a) If the outside air temperature is -30 °C or less, use "GLASSY".
(b) The concentration above is based on Mitsubishi Heavy Industries, Ltd. genuine LLC "GLASSY long life coolant (Ethylene glycol type)" or "PG GLASSY long life coolant (Non-amine type)".
For determining the accurate LLC concentration, refer to the instructions for the LLC used.

Importance of LLC

Today's trend is toward smaller and lighter engines offering greater output, lower fuel consumption and lower exhaust emission levels.
Conditions to which engine coolant is subjected, therefore, are becoming severer due to longer operating hours, higher coolant temperature and higher coolant circulating speed.
Many different materials such as steel, aluminum, copper, solder and rubber are used in the cooling system, and they are also subjected to the severe conditions described above. Those materials have different ionization characteristics, and this difference accelerates corrosion through the medium of engine coolant. To prevent such a problem, the use of LLC that contained the additive to prevent rust is very important.

Characteristics of LLC additive and important notes

LLC contains several chemicals in such proportions as to produce chemical reactions that suppress corrosion (ionization) of engine parts in contact with the coolant. LLC loses its effectiveness by hours of use as well as lapse of time.
Moreover, if the chemicals in LLC are not maintained, certain chemicals in the LLC become rapidly used up and result in dissolution of metals instead of protecting metals from corrosion. Consequently, other corrosion preventing chemicals react with dissolving metals and accelerate corrosion. This condition generates more severe corrosion than when plain soft water is used. This is a typical problem caused by the use of inappropriate LLC.

Examples of abnormalities caused by LLC (amine type)

Pitting of iron parts

Amines are generally effective in suppressing the rusting of ferrous metals, but they are said to cause problems for copper parts.
Dissolved copper (copper corrosion) in the cooling system deposits on iron parts and the copper deposits cause corrosion and then pitting on iron parts that have a high ionization characteristics due to galvanic or local-cell action.

Corrosion of aluminum parts

Silicate is highly effective in protecting aluminum against rusting. However, it is unstable in a solution in which the pH is 9 or lower, and can turn to gel and precipitate in the solution. For this reason, the pH is usually specified to be about 10 to ensure a high alkaline level.
This means, after silicate is used up, the high alkalinity causes chemical attacks on aluminum. To prevent this problem, proper maintenance of the coolant is required. For case example, rapid wear of mechanical seals in the water pump due to secondary effects of silicate gel formed. Corrosion of aluminum parts after silicate is consumed.

Pitting and clogging of the radiator

When LLC deteriorates or when its concentration in the coolant is too low, the anti-corrosion performance of LLC lowers and results in the corrosion of metals.Brass and solder tend to corrode faster than other metals, and corrosion of these metals is said to cause water leakage and clogs. Example: Holes and clogs in radiator

Chapter 7 MAINTENANCE SCHEDULE

How to use the maintenance schedule

Periodic inspection not only extends the service life of the engine but also serves to ensure safe operation. Be sure to conduct inspections and maintenance according to the maintenance schedule.

The maintenance schedule shows the standard service intervals. If you notice any abnormalities such as abnormal noise, black exhaust smoke, white exhaust smoke, extremely high temperature of exhaust gas, abnormal vibration, and fuel, oil or exhaust gas leakage, make sure to conduct the inspection and maintenance work, regardless of recommended service intervals in the "Maintenance schedule."

Note: Appropriate service intervals vary depending on the usage and operating conditions as well as consumption of fuel, oil and coolant. Check the operating record of the engine to determine the most appropriate service intervals. (Feel free to consult a dealer of Mitsubishi Heavy Industries, Ltd. regarding service intervals.)

Service the items at multiples of the original requirement. For example, at 1000 service hours, also service those items listed under every 250 service hours and every 50 service hours.

Items marked with * in the maintenance schedule require special tools or large equipment. For the servicing of those items, contact a dealer of Mitsubishi Heavy Industries, Ltd.

Maintenance schedule

Table 7-1 Maintenance schedule

Interval and Service item		Page
Every 50 service hours	Fuel tank - Drain water	8-2
	Air cleaner - Check	8-14
First 50 service hours for a new or overhauled engine	Engine oil and Oil filter - Replace	8-8
	Bolts and nuts on the engine - Retighten	*
Every 250 service hours	Engine oil and Oil filter - Replace	8-8
	Belt and belt tension - Inspect and Adjust	8-3
	Radiator fins - Check and Clean	8-13
	Add grease to link joints, etc.	*
Every 500 service hours	Fuel filter (in-line type fuel injection pump) - Replace	8-6
	Fuel system (distributor type fuel injection pump) - Bleed air	8-5
	Valve clearance - Inspect	*
	Cleaning the fuel tank (Every 500 service hours or Every 1 years)	*
	Checking glow plug	*
Every 1000 service hours	Starter - Inspect	8-18
	Alternator - Inspect	8-18
	Bolts and nuts on the engine - Retighten	*
Every 1500 service hours	Nozzle tip - Clean	*
Every 3000 service hours	Fuel injection nozzle - Check and Clean	*
	Turbocharger - Inspect	8-14
Every 2 years	Coolant - Change	8-11
As required	Pre-cleaner - Clean, Inspect and Replace	8-15
	Air cleaner element - Clean, Check and Replace	8-16
	Fuel filter - Drain water	8-3
	Fuel system (in-line type fuel injection pump) - Bleed air	8-4
	Fuel system (distributor type fuel injection pump) - Bleed air	8-5
	Specific gravity of battery electrolyte - Check	8-17

Chapter 8 PERIODIC INSPECTION AND MAINTENANCE PROCEDURES

Basic engine

Belt and belt tension - Inspect and Adjust

CAUTION

If defects such as cuts or surface separations are found during inspection, replace the belt.
Keep oil and grease away from the belt. They may cause the belt to slip and shorten the service life.
Excessive belt tension can cause rapid wear of the alternator bearing and shorten the service life of the belt.
Adjust the belt tension accurately by following the procedures below.

Belt - Inspect

1. Inspect the belt visually for separation or damage. If any abnormality is found, replace the belt with a new one.
2. Inspect belt tension (deflection).
   Push the belt downward at the midway between pulleys. If the deflection is 12 mm [0.47 in.], the tension is correct.
   Belt pushing force: Approx. 98 N {10 kgf} [22 lbf]
   If the deflection of belt is not within the standard, adjust the belt tension.

Belt tension (Alternator side) - Adjust

1. Remove the belt cover.
2. Loosen all retaining bolts of the alternator and adjusting plate.
3. Move the alternator to adjust the belt tension.
4. After adjusting the belt tension, tighten all retaining bolts of the alternator and adjusting plate.
5. Install the belt cover.

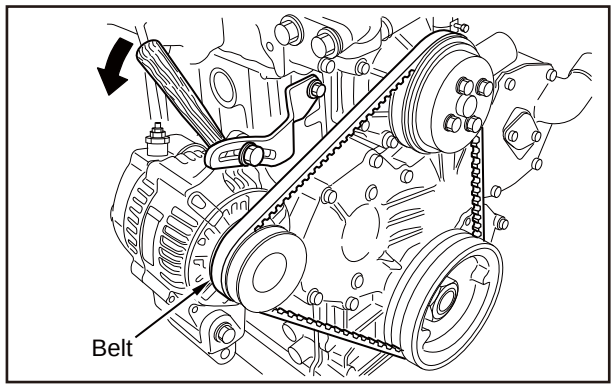


Fig. 8-1 Belt and belt tension - Inspect and Adjust

Fuel system

Fuel tank - Drain water

⚠ WARNING

When working around fuel, make sure there are no open flames, heaters or other fire hazards. Wipe off any spilled fuel completely. Spilled fuel can ignite and cause a fire.

CAUTION

Do not remove the strainer when filling the fuel. For fuel to be used, refer to "FUEL" (4-1).
Bleeding water procedure described below is a commonly used procedure. Some application may be equipped with different fuel tank.

If fuel gets mixed with particles of foreign materials such as dust, dirt, or water, it can cause not only decrease of output but also malfunctions of the fuel system. To avoid such a problem, drain fuel tank as described below.

1. Place a fuel tray (capacity of 2 L [0.5 U.S. gal.] or more) under the drain cock of fuel tank.
2. Open the drain cock of fuel tank and drain fuel at least 1 to 2 L [0.3 to 0.5 U.S. gal.].
3. Make sure that water and particles of foreign materials discharged with fuel. Close the drain cock.

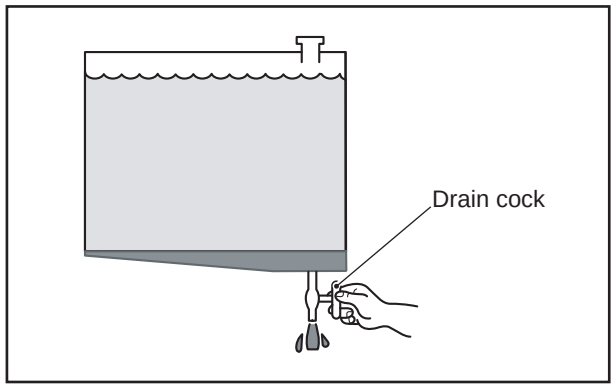


Fig. 8-2 Fuel tank - Drain water

Fuel filter - Drain water

⚠ WARNING

When handling fuel, make sure there are no open flames or other fire hazards near the engine.
Wipe off any spilled fuel completely.Spilled fuel can ignite and cause a fire.

Drain water for the fuel filter if the warning of water draining for fuel filter is occurred.

1. Place a drip tray under the drain hose.
2. Loosen the drain plug and drain water from the fuel filter.

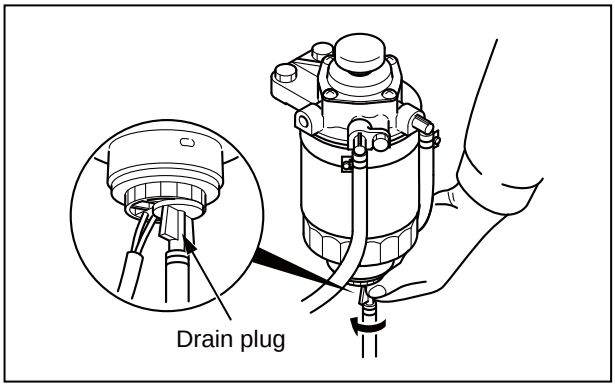


Fig. 8-3 Fuel filter - Drain water (1)

3. Feed fuel by pushing down on the priming pump (about seven strokes) to facilitate draining.
4. After draining, tighten the drain plug securely.
5. After drain the fuel filter, bleed the fuel system.
   For bleeding air from fuel system, refer to "Fuel system (distributor type fuel injection pump) - Bleed air" (8-5).

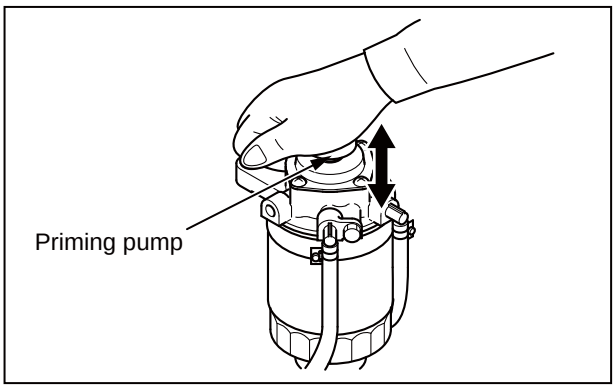


Fig. 8-4 Fuel filter - Drain water (2)

Fuel system (in-line type fuel injection pump) - Bleed air

⚠ WARNING

When fuel overflow from the air vent plug, wipe thoroughly with a cloth. Spilled fuel causes fire hazard
After bleeding, lock the priming pump securely.If the cap is not locked tightly, the priming pump can be damaged, causing a fuel leakage that could lead to a fire.

CAUTION

Tighten the priming pump before closing the air vent plug.
Do not close all air vent plugs and cocks before locking the priming pump, as the priming pump will not return to the original position due to internal pressure.

Bleed air at fuel filters and then at the fuel injection pump. Bleeding from upstream to downstream is effective for this job.

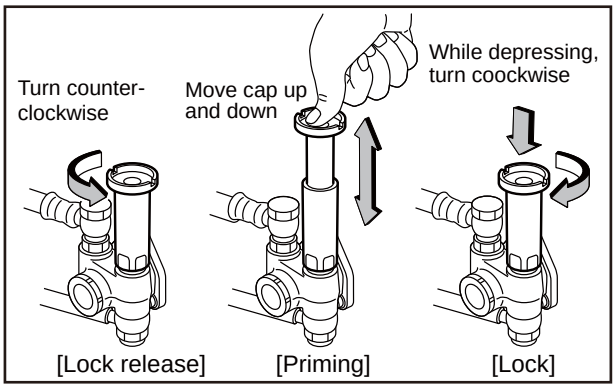


Fig. 8-5 Priming pump - Handle

Fuel filter - Bleed air

CAUTION

If air vent plugs, the thread portion of the bracket, or sealing washers are damaged, replace them with new ones.

1. Loosen the air vent plug on the fuel filter about 1.5 turns.
2. Turn the priming pump counterclockwise to unlock, and prime the fuel filter.
3. When the fuel from the air vent plug becomes free from air bubbles, stop priming and tighten the air vent plug to the specified torque.

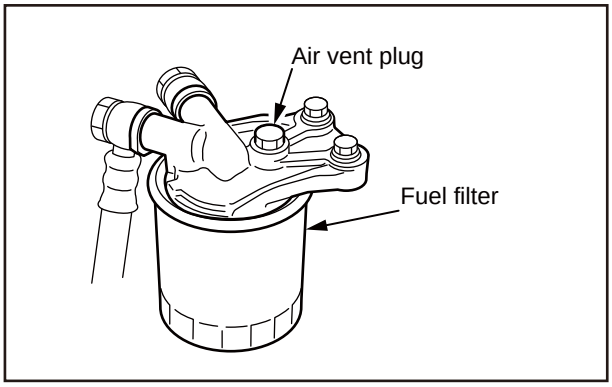


Fig. 8-6 Fuel filter - Bleed air

Fuel injection pump - Bleed air

1. Loosen the air vent plug on the fuel injection pump by rotating about 1.5 turns.
2. Move the priming pump up and down. When the fuel flow from the air vent plug becomes free of bubbles, push and turn the priming pump clockwise to lock.
3. Tighten the air vent plug on the fuel injection pump.

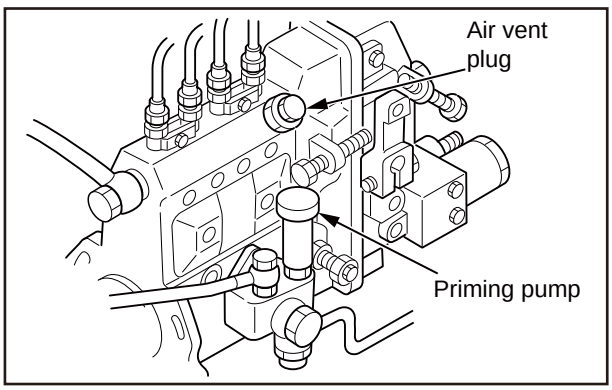


Fig. 8-7 Fuel injection pump - Bleed air

Fuel system (distributor type fuel injection pump) - Bleed air

WARNING

When handling fuel, make sure there are no open flames or other fire hazards near the engine.

When fuel overflows from the air vent plug, wipe thoroughly with a cloth.Spilled fuel can ignite and cause a fire.

After replacing fuel filter or draining water from fuel filter, or when running out of fuel, bleed the fuel system as follows:

1. Loosen the air vent plug on the fuel filter about 1.5 turns.
2. Apply a cloth to the air vent plug.

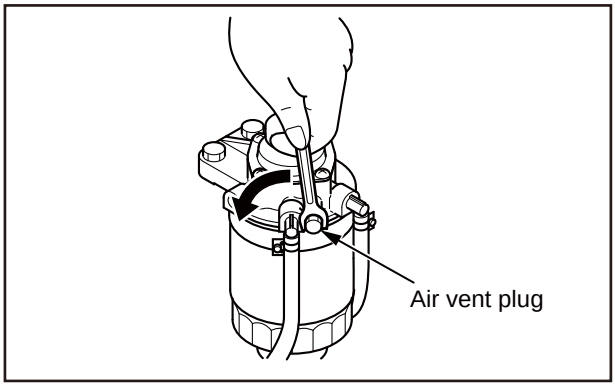


Fig. 8-8 Fuel filter - Bleed air (1)

3. Repeat pumping until the fuel flow from air vent plug becomes free of bubbles.
4. Repeat pumping until the fuel flow from air vent plug becomes free of bubbles.

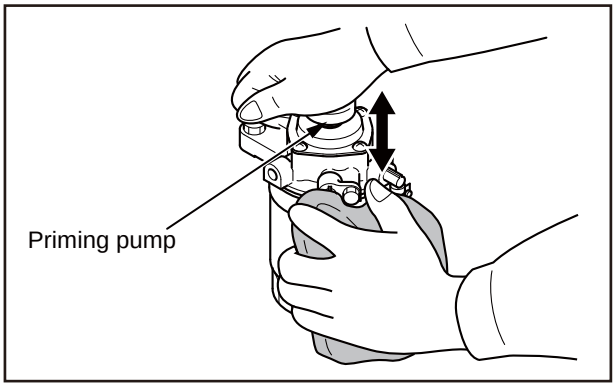


Fig. 8-9 Fuel filter - Bleed air (2)

Fuel filter (in-line type fuel injection pump) - Replace

⚠ WARNING

When handling fuel, make sure there are no open flames or other fire hazards near the engine. Wipe off any spilled fuel completely. Spilled fuel can ignite and cause a fire.

1. Clean the area around the fuel filters.
2. Place a fuel tray under the fuel filter.
3. Using a filter wrench, remove the fuel filters.
4. Wipe off fuel on the fuel filter cartridge mounting surface of the filter bracket with a waste cloth.
5. Check new fuel filters for proper seating of the gasket.

⚠ WARNING

Do not use a filter with the dented case. Fillter damage or fule leakage may occur and it can cause fire hazard.

6. Apply clean fuel to the gasket on the new fuel filter.
7. Install the fuel filter to the filter bracket.

CAUTION

Do not use a filter wrench to install the fuel filter.
Do not dent or scratch the fuel filter surfaces.

8. After installing the new fuel filter, bleed the fuel system.

Note: For bleeding fuel system, refer to "Fuel filter (in-line type fuel injection pump) - Replace" (8-6).

9. Start the engine and let it idle for several minutes.
10. Make sure that there is no fuel leakage during the engine operation. If fuel leakage is found, loosen the fuel filter and check the gaskets for damage. If there is no damage, retighten the fuel filter.

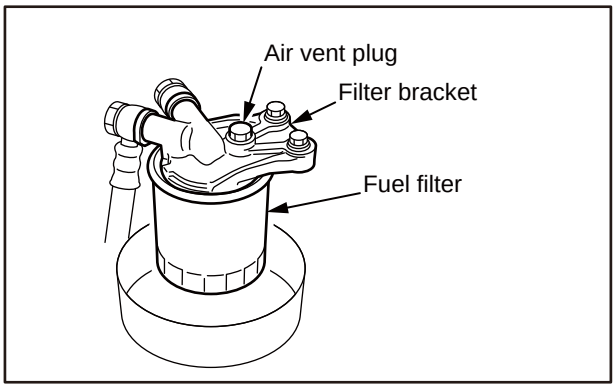


Fig. 8-10 Fuel filter - Replace

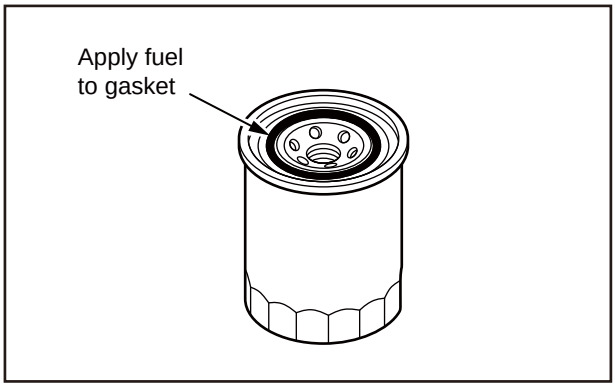


Fig. 8-11 Fuel filter

Fuel filter (distributor type fuel injection pump) - Replace

⚠ WARNING

When handling fuel, make sure there are no open flames or other fire hazards near the engine.Wipe off any spilled fuel completely.Spilled fuel can ignite and cause a fire.

1. Clean the area around the fuel filters.
2. Disconnect the fuel filter level sensor from its connector.
3. Place a fuel tray under the fuel filter.
4. Loosen the drain plug and drain fuel from the fuel filter.
5. Remove the level sensor from the fuel filter.
6. Remove the fuel filter element.
7. Wipe off fuel on the fuel filter element mounting surface of the fuel filter body with a waste cloth.
8. Check new fuel filter elements for proper seating of the gasket.

⚠ WARNING

Do not use a filter with the dented case.Fillter damage or fule leakage may occur and it can cause fire hazard.

9. Install the fuel filter element to the filter body.

CAUTION

Do not dent or scratch the fuel filter surfaces.

10. Using new O-ring, install the level sensor to the fuel filter element.
11. After installing the new fuel filter, bleed the fuel system.

Note: For bleeding fuel system, refer to "Fuel system (distributor type fuel injection pump) - Bleed air" (8-5).

12. Start the engine and let it idle for several minutes.
13. Make sure that there is no fuel leakage on mounting sureface of fuel filter element. If fuel leakage is found, loosen the fuel filter and check the gaskets for damage. If there is no damage, retighten the fuel filter.

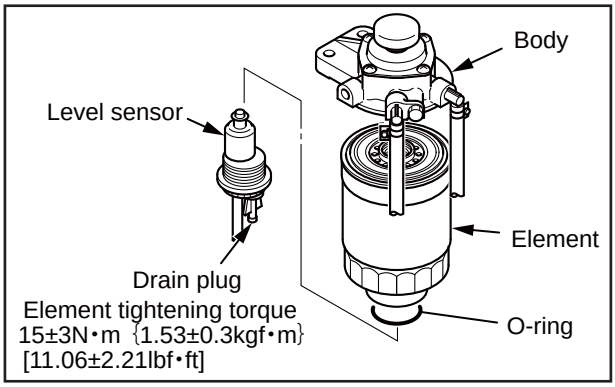


Fig. 8-12 Fuel filter - Replace

Lubricating system

Engine oil and Oil filter - Replace

⚠ CAUTION

When draining oil or changing the oil filter, wear gloves. Hot engine oil and parts may cause burns.

CAUTION

Do not dump waste oil. It is forbidden by law. For disposal of waste oil, consult a dealer of Mitsubishi Heavy Industries, Ltd.

Change engine oil and the oil filter at the same time.

Also checking and analyzing the oil properties is recommended when changing the engine oil.

Do not reuse the oil filter element, as it is a paper type.When replacing filters, always replace gasket with new ones.

Engine oil - Drain

After the engine has stopped, drain engine oil from the engine oil drain port.

Note: Draining by suction should be avoided.

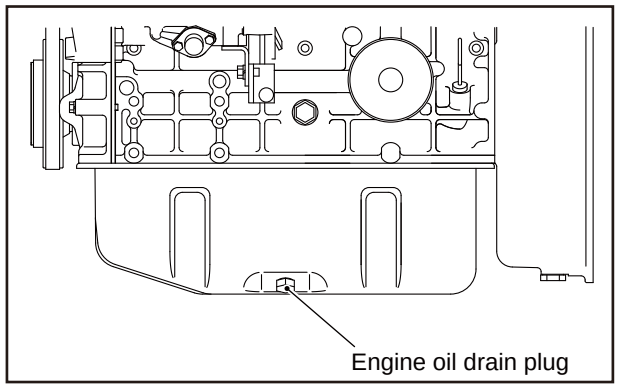


Fig. 8-13 Engine oil drain plug

Engine oil - Refill

1. Make sure that the oil drain plug is tightened.
2. Remove the oil filler cap.
3. Fill the engine oil pan with specified engine oil to the specified level.

Note: For engine oil, refer to "ENGINE OIL" (5-1). For engine oil capacity, refer to "MAIN SPECIFICATIONS" (12-1).

4. Check the oil level in the oil pan as follows:
5. Pull out the oil level gauge, and wipe it with a waste cloth.
6. Insert the oil level gauge fully into the oil level gauge guide, then pull out the gauge again.
7. The proper oil level is between the high and low marks on the oil level gauge. If the oil level is low, add engine oil of the specified type.
8. Check the oil pan and other area for oil leakage. Repair any oil leakage found.
9. Run the engine with starter for approx. 10 seconds while pulling the stop lever and feed engine oil to all parts of engine. Stop the operation for 1 minute, then, repeat the operation two or three times. Circulate engine oil to all parts of the engine.

Note: Prepare for the Cooling system.

10. Check the oil level with the oil level gauge again, and add oil to the specified level.

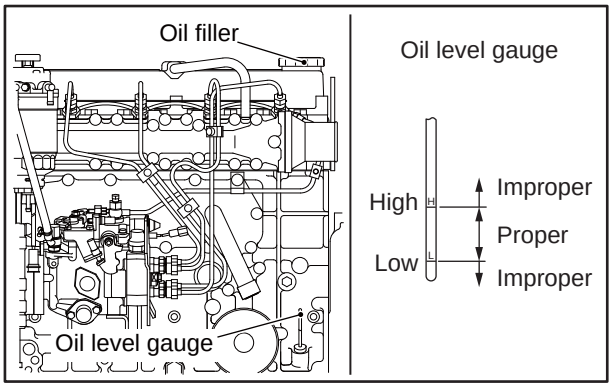


Fig. 8-14 Engine oil - Refill

Oil filter - Change

WARNING

Do not use a dented filter cartridge.
Filter damage or fule leakage may occur while engine is running and it can cause fire hazard.

CAUTION

To avoid damage to the filter, do not use a filter wrench when installing. Tighten the filter by hand.

1. Clean around the oil filters.
2. Place a drip pan under the oil filter.
3. Using a filter wrench, remove the oil filter.

Note: Check the element of the oil filter that has been removed. If metal particles are found, consult a dealer of Mitsubishi Heavy Industries, Ltd.

4. Thoroughly wipe off oil on the mounting surface of oil filter with a waste cloth.
5. Check the new oil filter for proper seating of gasket.
6. Apply clean engine oil to gasket.
7. Install the oil filter. When the filter gasket contacts the mounting surface of filter, tighten the filter with specified torque.

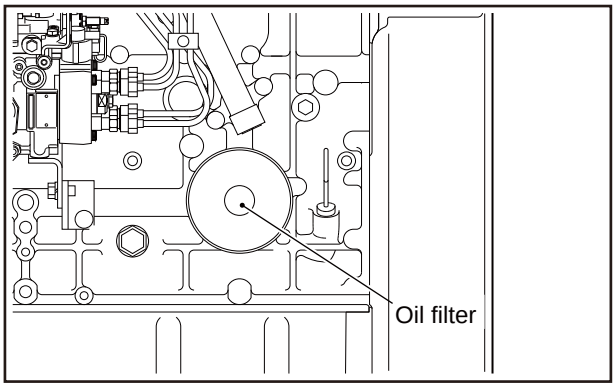


Fig. 8-15 Oil filter - Change

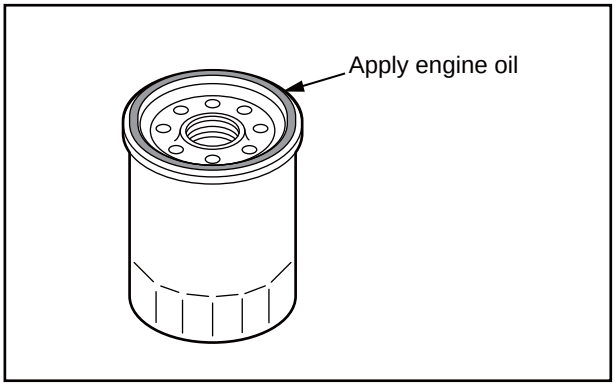


Fig. 8-16 Oil filter

Cooling system

Coolant - Change

⚠ WARNING

Remove the radiator filler cap only after the engine has cooled to room temperature. Place a waste cloth over the cap, and loosen the cap about a half-turn or stand the lever to the upright position to release internal pressure. Never open the radiator filler cap while the engine is hot, otherwise the steam or hot coolant spurts out and you may be scald with it.
Coolant (containing LLC) drained from the engine is toxic. Never dispose of coolant into regular sewage. For disposal of used coolant, consult a dealer of Mitsubishi Heavy Industries, Ltd. or a industrial waste disposer.

CAUTION

The service life of LLC is 2 years. Be sure to change coolant at least once every 2 years.

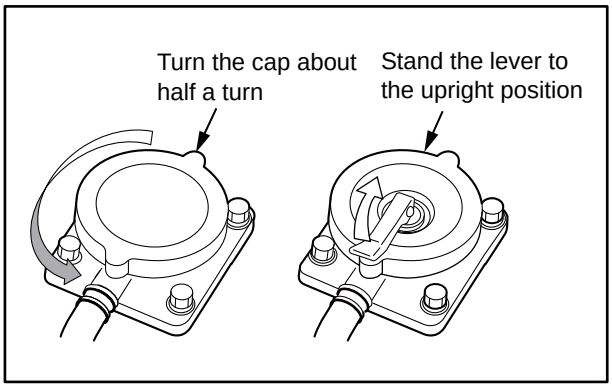


Fig. 8-17 Radiator filler cap

Coolant - Drain

1. When draining coolant immediately after engine operation, idle the engine in low gear for 5 to 6 minutes until the coolant temperature drops to 70 to 80 °C [158 to 176 °F].
2. Open the radiator filler cap.
3. Place coolant receiving can under the drain cocks and plugs, and open the coolant drain cocks and plugs to drain the coolant.

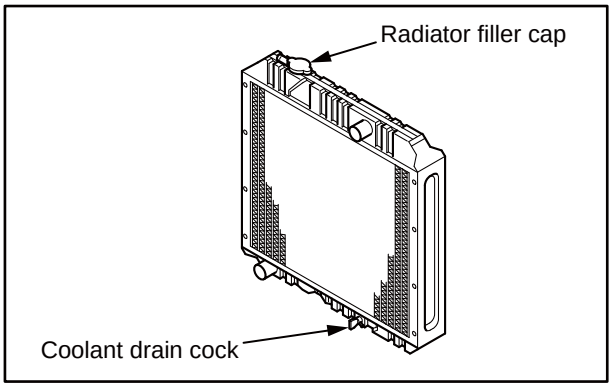


Fig. 8-18 Coolant drain cock (radiator)

Cooling system - Clean

CAUTION

Clean the cooling system when operating the engine first time, or restarting the engine after storage with coolant drained.

1. Close coolant drain cocks and plugs.
2. Pour in a cleaning solution (a solution that is non-corrosive to rubber and metals) in the cooling system, and operate the engine at 800 to 900 min^{-1} for about 15 minutes, then drain the cleaning solution.
3. Close coolant drain cocks and plugs.
4. Pour in fresh water, and operate the engine at 800 to 900 min^{-1} for about 10 minutes.
   Repeat rinsing until the draining water becomes clear and clean.

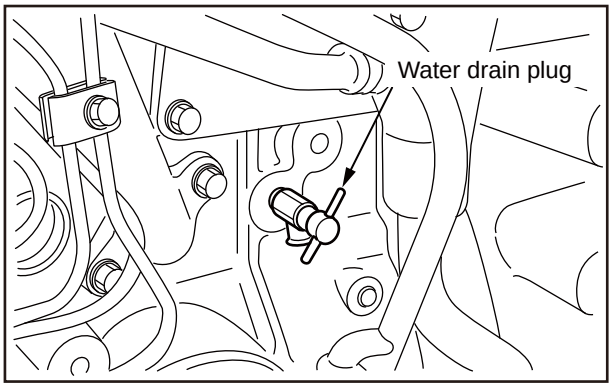


Fig. 8-19 Coolant drain plug (engine)

Coolant - Refill

1. Tighten the coolant drain cocks and plugs.
2. Remove the radiator filler cap, and pour in undiluted LLC.

Note: Determine the amounts of LLC and water to be added by using the LLC concentration chart.
For the coolant, refer to "COOLANT" (6-1). For the coolant capacity, refer to "MAIN SPECIFICATIONS" (12-1).

3. Pour in water (soft water with minimal impurities, such as tap water) slowly to "FULL" level line.
4. Check the radiator and other parts for coolant leakage. If any coolant leakage is found, repair it.
5. When coolant reaches "FULL" level line, close the radiator filler cap securely.
6. Run the engine with starter for approx. 10 seconds while pulling the stop lever.
   Stop the operation for 1 minute, then, repeat the operation two or three times to bleed the cooling system.
7. Check the coolant level in the radiator.
   If the engine is equipped with a reserve tank, fill the reserve tank with coolant to "FULL" level line as well.

CAUTION

Always use the coolant with the same LLC concentration.

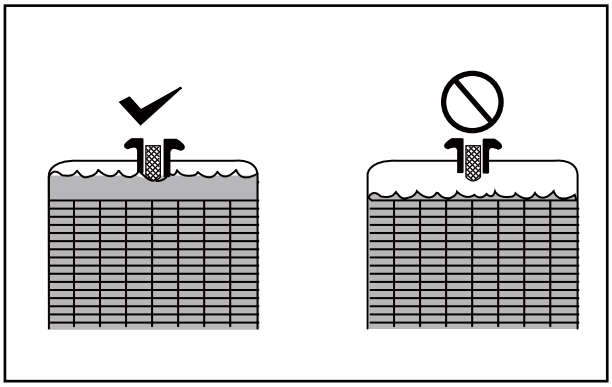


Fig. 8-20 Radiator coolant level

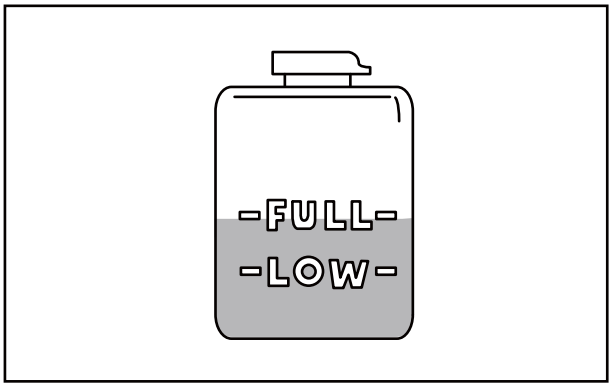


Fig. 8-21 Reserve tank

Radiator fins - Check and Clean

⚠ CAUTION

When handling compressed air, wear safety goggles, a hardhat, gloves and other necessary protective gear. Works without wearing proper protective gear could result in serious injuries.

Check the radiator fins for holes and cracks.
To clean the radiator fins, blow compressed air from the opposite direction of the normal air flow.

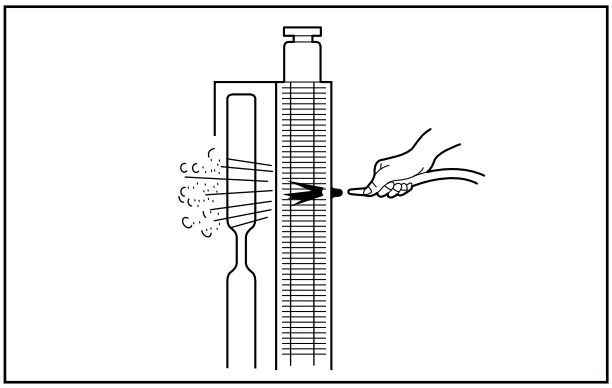


Fig. 8-22 Radiator fins - Clean

Inlet and exhaust systems

Air cleaner - Check

CAUTION

Checking procedure described below is a commonly used procedure. Some application may be equipped with different air cleaner.

1. Check the air cleaner indicator for the element clog.
2. If the element is clogged, the red signal mark is visible.
3. Immediately clean or replace the air cleaner element when the signal turns red.

Note: For cleaning of the air cleaner element, refer to "Air cleaner element - Clean, Check and Replace" (8-16).

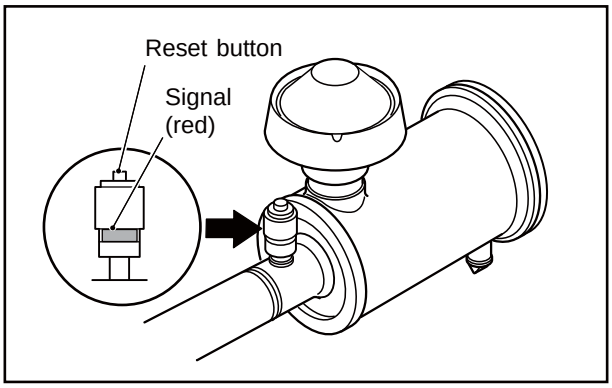


Fig. 8-23 Air cleaner - Check

Turbocharger - Inspect

CAUTION

Check the turbocharger when the engine is cold. Also, make sure that the compressor wheel is not rotating before inspecting the turbocharger.

CAUTION

If the color of the exhaust gas is abnormal, also inspect the turbocharger.

Disconnect the pipe from the air inlet side. Hold the compressor wheel nut by hand and turn the wheel to check for looseness or abnormal noise. Replace the turbocharger if looseness or abnormal noise is found.

Note: When removing and inspecting turbocharger, contact a dealer of Mitsubishi Heavy Industries, Ltd.

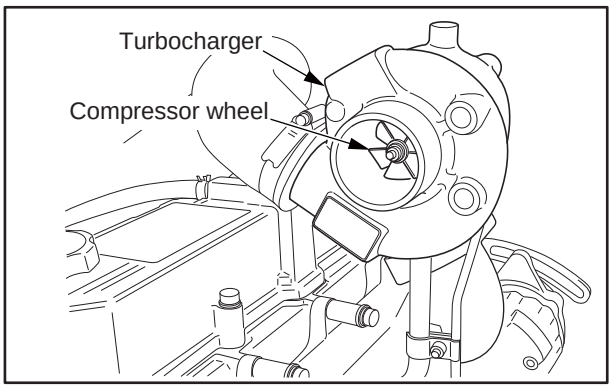


Fig. 8-24 Turbocharger - Inspect

Pre-cleaner - Clean, Inspect and Replace

⚠ CAUTION

Never service the pre-cleaner while the engine is running. Servicing the air cleaner while the engine is running can cause particles of foreign matter to enter the engine and result in rapid wear of parts, leading to a shorter service life of the engine.

The pre-cleaner is equipped to the silencer of the turbocharger to prevent foreign items from sucking and keep the engine clean for optimum performance. Be sure to clean the pre-cleaner as described below.

1. Remove the pre-cleaner from the silencer, and hand-wash the pre-cleaner with a mild detergent.
2. Rinse the pre-cleaner with fresh water.
3. After drying thoroughly, inspect the pre-cleaner for defect. If any defect are found, replace the pre-cleaner with a new one.
4. After cleaning, inspecting or changing the pre-cleaner, reinstall it to the silencer.

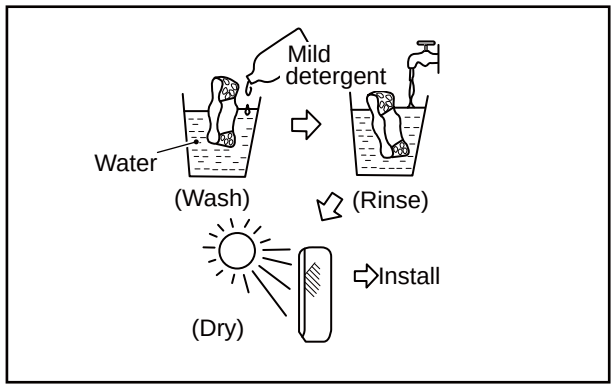


Fig. 8-25 Pre-cleaner - Clean

Air cleaner element - Clean, Check and Replace

⚠ CAUTION

When handling compressed air, wear safety goggles, a dust mask, a hardhat, gloves and other necessary protective gear. Works without wearing proper protective gear could result in serious injuries.
Never service the air cleaner while the engine is running. Servicing the air cleaner while the engine is running can cause particles of foreign material to enter the engine and result in rapid wear of parts, leading to a shorter service life of the engine.Never knock or hit the element.

CAUTION

Cleaning, inspecting and replacing procedure described below is a commonly used procedure. Some application may be equipped with different air cleaner.

1. Remove the air cleaner cap and wing bolt.
2. Remove the air cleaner element from the body.
3. Blow compressed air (0.69 MPa {7 kgf/cm^2} [100 psi] or lower) onto the inside surface of the element to remove foreign materials.
4. To remove dust stuck on the air cleaner element, blow dry compressed air onto the outside surface from a distance.
   Blow compressed air on the inside surface toward the outside along the pleats. Then, blow compressed air on the outside and inside surface again.
5. After cleaning, hold the air cleaner element near a light bulb to illuminate the inside, to check for defects such as cuts, pinholes or local wear.
6. If any defect is found, replace the air cleaner element with a new one.
7. Reassemble the air cleaner element as it is.

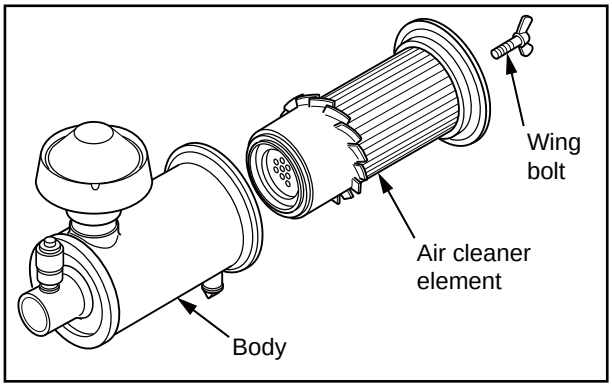


Fig. 8-26 Air cleaner element - Remove

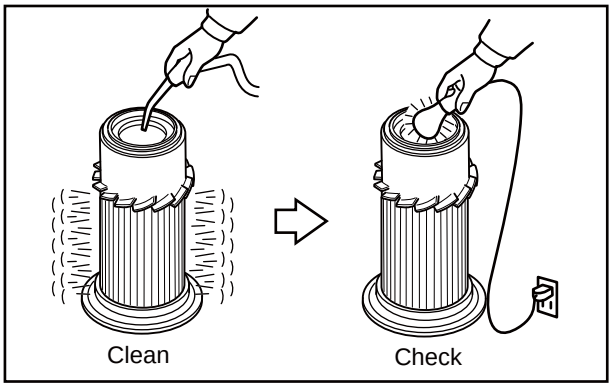


Fig. 8-27 Air cleaner element - Clean and Check

CAUTION

If defects such as cuts, pinholes or local wear are found in the element, or if the air cleaner indicator shows a red sign soon after the cleaned element is installed, change it for new one.

After cleaning or replacing the air cleaner element, press the reset button to reset the indicator.

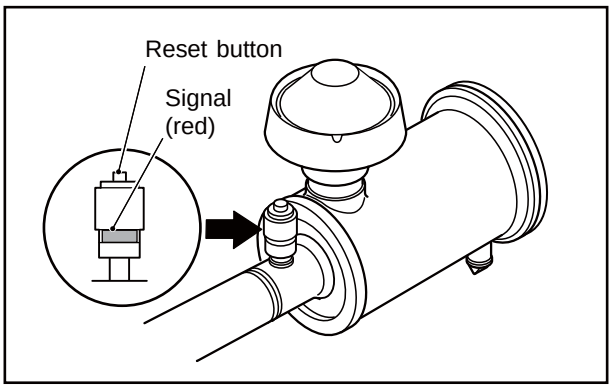


Fig. 8-28 Air cleaner - Check

Electrical system

Battery - Inspect

⚠ CAUTION

If battery electrolyte is spilled on your skin, flush immediately with plenty of water. If battery electrolyte enters the eyes, flush them immediately with lots of fresh water and seek medical attention at once.

Do not use open flames or other fire hazards near the battery. When handling the battery, be careful of sparks generated by accidental shorting.

Battery electrolyte level - Inspect

Battery electrolyte evaporates during use and the f electrolyte level gradually decreases. The proper electrolyte surface level is between the "LOWER LEVEL" and "UPPER LEVEL" lines.

For the battery without level lines, the proper electrolyte surface level is about 10 to 15 mm [0.394 to 0.591 in.] above the top of the plates.

If the electrolyte level is low, remove the caps and add distilled water to the proper level.

Note: When adding distilled water, pour in carefully.

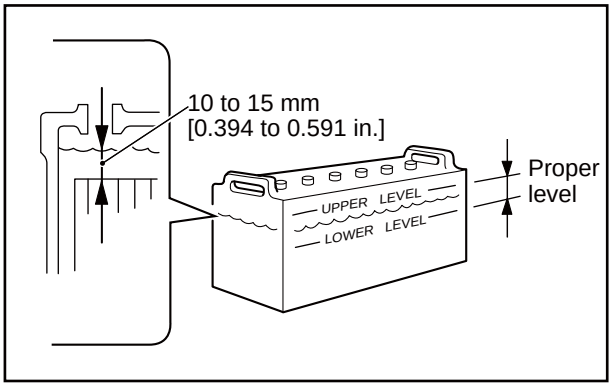


Fig. 8-29 Battery electrolyte level - Inspect

Specific gravity of battery electrolyte - Check

If the specific gravity measured at 20 °C [68 °F] is lower than 1.22, then charge the electrolyte.

Table 8-1 Specific gravity of electrolyte

Specific gravity at 20 °C [68 °F]	Condition	Remedy
From 1.26 to 1.28	Fully charged	-
From 1.22 to 1.26	Charged	Charge
Less than 1.22	Discharged	Charge

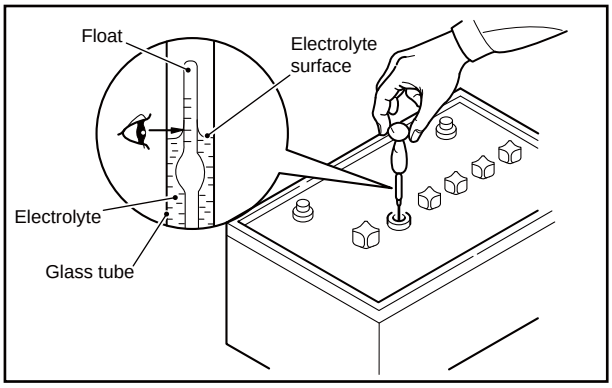


Fig. 8-30 Specific gravity of battery electrolyte - Check

Starter - Inspect

Visually check the starter for damage.

If the starter is dusty, blow dirt using compressed air.

Note: If the starter is defective, consult a dealer of Mitsubishi Heavy Industries, Ltd.

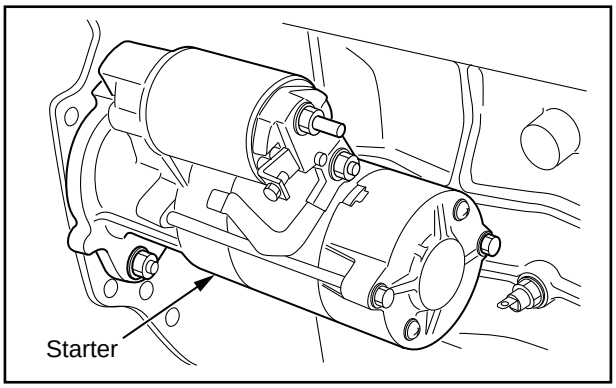


Fig. 8-31 Starter - Inspect

Alternator - Inspect

Visually check the alternator for damage.

If the alternator is dusty, blow foreign material using compressed air.

Remove the belt and check that the movement is smooth when rotating the pulley by hand.

Note: If the alternator is defective, consult a dealer of Mitsubishi Heavy Industries, Ltd.

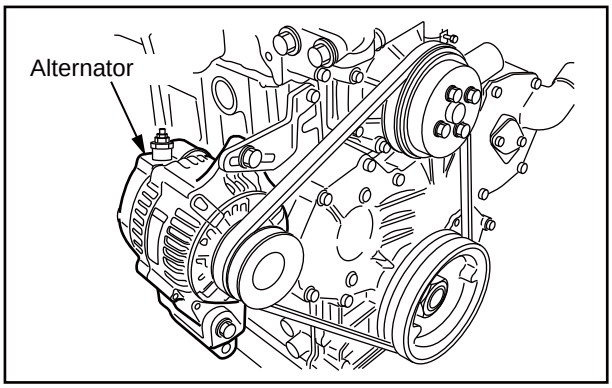


Fig. 8-32 Alternator - Inspect

Chapter 9 LONG-TERM STORAGE

Long-term storage

The following describes how to store the engine in a non-operable condition for 3 months or more and in an operable condition for 3 months or more.

If the engine has been left unattended for 3 months or more, the internal engine parts can rust, and that may cause damage to the engine.

When storing the engine for an extended period of time, be sure to follow the directions below.

Storing the engine in a non-operable condition for 3 months or more

Preparation for storage

1. Drain the engine oil in-use, pour new oil.
2. Prepare a fuel mixture containing 50 % rust-preventive oil (NP-9), and fill the fuel tank with it.
3. Operate under non-load minimum engine speed for 5 to 10 minutes.
4. Immediately before stopping the engine, spray volatile corrosion inhibitor (VCI) through the inlet port to prevent rust on the air intake system.
5. With the engine stopped, drain the fuel mixture from the fuel tank.
6. Apply rust-preventive oil (NP-3) liberally on the exposed sections of the machining.
7. Seal the air inlet, exhaust outlet, breather and other openings with an adhesive cloth tape.
8. Cover the entire engine.

Note: (a) Store the engine in a well-ventilated indoor area.

(b) It is not necessary to drain coolant since it contains LLC. (Add LLC to increase the concentration to between 30 to 60 %.)

(c) Post a sign at an easily noticeable place to warn that the rust-preventive oil in the engine must be replaced with engine oil, and the fuel tank must be filled with fuel before operating the engine for the first time after storage.

(d) New engine oil can substitute for rust-preventive oil (NP-10-2) of lubrication system.

Recommended rust-preventive oil and corrosion inhibitor

Table 9-1 Recommended rust-preventive oil and corrosion inhibitor

JIS No.		Recommended product	Application
K 2246	NP-3	Nippon Oil Corporation Anti Rust P-1600	Prevention of rust on exposed machine surfaces
	NP-9	Nippon Oil Corporation Anti Rust P-2400	Prevention of rust in fuel system
	NP-10-2	Nippon Oil Corporation Anti Rust P-230	Prevention of rust in lubricating system
Z 1519	-	Ryoukou Kagaku VCI Diana ND volatile corrosion inhibitor	Prevention of rust in air intake system

Maintenance during storage

Charge the battery once a month. First, check the battery electrolyte for proper level and then charge the battery.

Using the engine after storage

1. Remove the cover from the engine.
2. Connect a fully charged battery.
3. Remove the covers from the starters and alternator.
4. Adjust the tension of belt.

Note: Inspect and adjust V-belt tension. Refer to "Belt and belt tension - Inspect and Adjust" (8-XX).

5. Remove sealing tapes from the openings of the engine.
6. Connect pipes.

Note: For engine oil, refer to "ENGINE OIL" (5-1).

7. Fill the fuel tank with fuel, and bleed the fuel system.

Note: For bleeding fuel system, refer to "Fuel system (in-line type fuel injection pump) - Bleed air" (8-4) or "Fuel system (distributor type fuel injection pump) - Bleed air" (8-5).

8. Inspect the entire engine.
9. Remove the rocker covers, and lubricate the valve mechanisms.
10. Run the engine with starter for approx. 10 seconds while pulling the stop lever. Stop the operation for approx. 1 minute, then, repeat the operation two or three times.
11. Make sure the engine oil pressure rises.
12. Conduct a warm up operation for a sufficient duration.

Note: For starting the engine, refer to "Starting" (3-4).

13. Apply load and increase the engine speed to the rated speed.

Storing the engine in an operable condition for 3 months or more

When the engine is not operated during storage of 3 months or more, internal engine parts can rust and lose oil film. As a result, the engine can seize when it is started after storage. To prevent such a risk, the engine must be operated periodically during storage.

Operating the engine for maintenance

Operate the engine for maintenance at least once a month as described below.

1. Run the engine with starter for approx. 10 seconds while pulling the stop lever. Stop the operation for approx. 1 minute, then, repeat the operation two or three times.
2. Make sure the engine oil pressure rises.
3. Operate the engine about 5 to 10 minutes under no load as the maintenance operation.

Note: For starting the engine, refer to "Starting" (3-4).

Lifting the engine

⚠ WARNING

To lift the engine, use wire ropes, shackles and slings capable of supporting the weight of the engine.
Attach the wire rope to the hangers provided on the engine using a correct sling.
Keep the engine balanced during lifting by considering the engine's center of gravity.
Keep the angle formed by slings attached to hangers within 60°. If the angle exceeds this limit, excessive load could be imposed on the hangers and this could damage the hangers and result in a serious accident.
Attach wire ropes to the hangers after removing the pipe cover and the insulator near the hangers. To prevent wire ropes from contacting the engine, use a cloth or other soft padding.

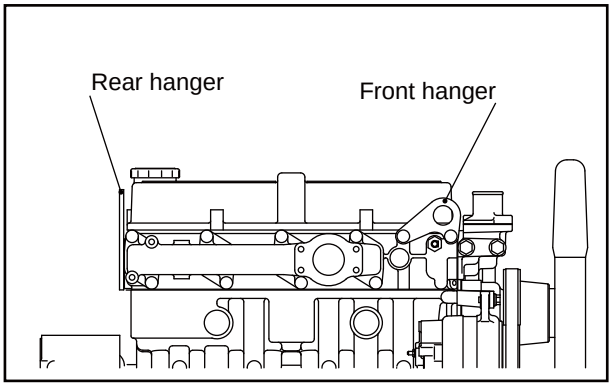
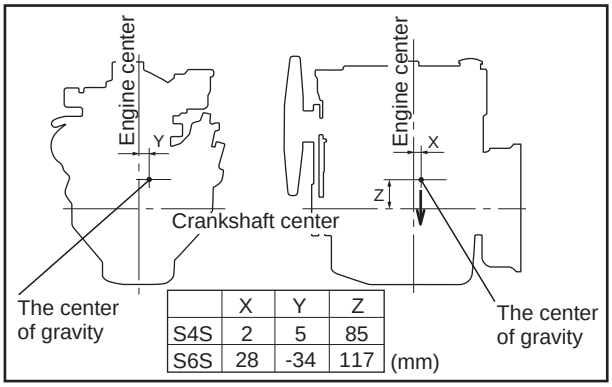


Fig. 10-1 Hangers



	X	Y	Z
S4S	2	5	85
S6S	28	-34	117

(mm)

Fig. 10-2 Engine's center of gravity (standard specification)

Chapter 11 TROUBLESHOOTING

General precautions

Contact a dealer of Mitsubishi Heavy Industries, Ltd. for repair service

Repairing a malfunctioning engine may require special equipment or involve potentially dangerous work, except for relatively simple procedures such as the change and addition of fuel, engine oil and coolant. In the event of the engine failure, contact a dealer of Mitsubishi Heavy Industries, Ltd.

Considerations before work

Before troubleshooting, consider possible causes of the problem and try to find out if the same problem has occurred in the past.

Check the parts that may be causing the problem in the most efficient order.

When disassembling a component, pay close attention to the disassembly sequence so that you can reassemble the component in reverse order of disassembly.

Cautions against contamination

Dust and foreign materials are the most common cause of rapid wear of parts.

When disassembling a component, take measures to prevent dust and foreign materials from entering the component being disassembled.

Cautions regarding parts handling

Handle parts carefully.

When replacing parts, use only genuine parts by referring to the parts catalogue.

Work safety

Be sure to use wrenches of the correct size. Using a wrench of the wrong size not only damages nuts but can also cause the personal injury.

Use correct tools and perform work with utmost caution.

Be sure to accurately estimate the weight of the part being dismounted. If the removed part is much heavier than you have estimated, it may fall down during lifting and can result in the damage to the parts or personal injury.

Troubleshooting

The starter does not crank or cranks slowly, resulting in start failure

Table 11-1 The starter does not crank or cranks slowly, resulting in start failure

Cause		Remedies
Electrical system	Faulty wire connection	♦Check the DC fuse. ♦Check wiring connection between battery, starter and starter switch.
	Insufficiently charged battery	♦Check alternator. (Refer to P8-18) ♦Check and adjust belt. (Refer to P8-1)
	Faulty battery	♦Check specific gravity of battery electrolyte. (Refer to P8-17) ♦Charge battery. ♦Change battery.
	Faulty starter or starter relay	♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Lubricating system	Oil viscosity too high	♦Use appropriate engine oil. (Refer to P5-1)
	Excessive oil	♦Check amount of engine oil and lubrication system. (Refer to P3-2)
Engine mechanical	Rapid wear of sliding parts, or locked	♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.

The starter cranks, but the engine does not start

Table 11-2 The starter cranks, but the engine does not start

Cause		Remedies
Fuel system	Run out of fuel, blocked pipe	♦Inspect fuel tank, supply fuel, bleed air. (Refer to P8-2) ♦Check fuel pipes, valves.
	Improper fuel property	♦Use appropriate fuel. (Refer to P4-1) ♦Remove dust, water impurities. (Refer to P8-2)
	Fuel leakage in fuel pipes and injection pipes.	♦Check faults and retighten fuel pipes and injection pipes. ♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Clogged fuel filter	♦Inspect and replace fuel filter. (Refer to P8-6) or (Refer to P8-7) ♦Gauze filter - Clean
	Faulty fuel feed pump	♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection pump	♦Check the rack movement. ♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection nozzle	♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Air intake system	Insufficient amount of air	♦Clean, inspect and replace pre-cleaner. (Refer to P8-15) ♦Clean, inspect and replace air cleaner element. (Refer to P8-16)
Control system	Faulty governor	♦Fuel control link - Check ♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Basic engine	Low compression pressure	♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.

Output decrease

Table 11-3 Output decrease

Cause		Remedies
Fuel system	Improper fuel property	⬧Use appropriate fuel. (Refer to P4-1)
	Clogged fuel filter	⬧Inspect and replace fuel filter. (Refer to P8-6) or (Refer to P8-7) ⬧Gauze filter - Clean
	Faulty fuel feed pump	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection pump	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection nozzle	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection timing	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Improper amount of injected fuel	⬧Check fuel injection pump rack stroke. ⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Cooling system	Overheat, overcooled	⬧Check fan and radiator. ⬧Check control system. ⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Inlet and exhaust systems	Insufficient amount of air	⬧Check turbocharger. (Refer to P8-14) ⬧Clean, inspect and replace pre-cleaner. (Refer to P8-15) ⬧Clean, inspect and replace air cleaner element. (Refer to P8-16) ⬧Check intake air pressure and leakage of intake air. ⬧Check intake air temperature and ventilation device. ⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Increase resistance of exhaust air.	⬧Check turbocharger. (Refer to P8-14) ⬧Check exhaust pipes and silencer. ⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Basic engine	Low compression pressure	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty valve timing	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Rapid wear of sliding parts	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Control system	Faulty governor control	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.

Exhaust smoke is white or blue

Table 11-4 Exhaust smoke is white or blue

Cause		Remedies
Fuel system	Improper fuel property	•Check cetane index, and use appropriate fuel. (Refer to P4-1)
	Faulty fuel injection timing	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection nozzle	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Uneven fuel injection	•Check ignition noise, exhaust smoke temperature. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Incorrect fuel injection timing	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Lubricating system	Combustion of engine oil	•Check amount of engine oil and lubrication system. (Refer to P3-2) •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Cooling system	Overcooled	•Check radiator. (Refer to P8-13) •Check control system. •Thermostat - Inspect •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Basic engine	Faulty valve timing	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Low compression pressure	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.

Exhaust smoke is black or charcoal

Table 11-5 Exhaust smoke is black or charcoal

Cause		Remedies
Fuel system	Improper fuel property	⬧Use appropriate fuel. (Refer to P4-1)
	Faulty fuel feed pump	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection pump	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection nozzle	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection timing	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Uneven fuel injection	⬧Check exhaust smoke temperature. ⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Inlet and exhaust systems	Insufficient amount of air	⬧Check turbocharger. (Refer to P8-14) ⬧Clean, inspect and replace pre-cleaner. (Refer to P8-15) ⬧Clean, inspect and replace air cleaner element. (Refer to P8-16) ⬧Check intake air pressure and leakage of intake air. ⬧Check intake air temperature and ventilation device. ⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Increase resistance of exhaust air.	⬧Check turbocharger. (Refer to P8-14) ⬧Check exhaust pipes and silencer. ⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Basic engine	Low compression pressure	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty valve timing	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Rapid wear of sliding parts	⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Control system	Increase in load	⬧Check control system. ⬧Consult a dealer of Mitsubishi Heavy Industries, Ltd.

Fuel consumption is high

Table 11-6 Fuel consumption is high

Cause		Remedies
Fuel system	Faulty fuel injection nozzle	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty fuel injection timing	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Improper fuel property	•Use appropriate fuel. (Refer to P4-1)
	Fuel leakage in fuel pipes and injection pipes.	•Check faults and retighten fuel pipes and injection pipes. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Cooling system	Overcooled	•Check radiator. (Refer to P8-13) •Check control system. •Thermostat - Inspect •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Inlet and exhaust systems	Insufficient amount of air	•Check turbocharger. (Refer to P8-14) •Clean, inspect and replace pre-cleaner. (Refer to P8-15) •Clean, inspect and replace air cleaner element. (Refer to P8-16) •Check intake air pressure and leakage of intake air. •Check intake air temperature and ventilation device. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Increase resistance of exhaust air.	•Check turbocharger. (Refer to P8-14) •Check exhaust pipes and silencer. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Basic engine	Low compression pressure	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty valve timing	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Rapid wear of sliding parts	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.

Engine oil consumption is high

Table 11-7 Engine oil consumption is high

Cause		Remedies
Fuel system	Faulty fuel injection timing	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Lubricating system	Oil leakage to the outside of engine	•Check oil leakage. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Engine oil viscosity too low	•Use appropriate oil viscosity. (Refer to P5-3)
	Engine oil temperature is high.	•Check amount of engine oil and lubrication system. (Refer to P3-2) •Check oil cooler and oil thermostat. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Cooling system	Overheating	•Check radiator. (Refer to P8-13) •Check control system. •Thermostat - Inspect •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Inlet and exhaust systems	Spread oil to intake part	•Check oil leakage to the turbocharger. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Wear of valve operating system	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Basic engine	Wear of sliding parts	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Control system	Increase in load	•Check control system. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.

Overheating

Table 11-8 Overheating

Cause		Remedies
Cooling system	Low coolant level	•Check coolant leakage. •Check coolant level. (Refer to P3-3)
	Faulty water pump operation	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty thermostat operation	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty radiator operation	•Check and clean radiator and radiator filler cap. (Refer to P8-13)
Control system	Increase in load	•Check fuel injection pump rack stroke. •Check control system. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Basic engine	Rapid wear of sliding parts	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.

Low engine oil pressure

Table 11-9 Low engine oil pressure

Cause		Remedies
Lubricating system	Insufficient amount of engine oil	•Check amount of engine oil and lubrication system. (Refer to P3-2)
	Faulty engine oil property (viscosity)	•Analyze oil property. Use appropriate engine oil. (Refer to P5-1)
	Oil temperature too high	•Check coolant system. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Oil filter clogged	•Inspect and replace oil filter. (Refer to P8-8)
	Faulty oil pump operation	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Faulty relief valve operation	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Control system	Faulty pressure unit operation	•Check control system and wire. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
Basic engine	Increase in load	•Check control system. •Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Rapid wear of sliding parts	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.
	Increase clearance of sliding part.	•Consult a dealer of Mitsubishi Heavy Industries, Ltd.

When fuel has run out

When fuel runs out while engine is running and the engine has stopped, restart the engine as described below.

1. Return the starter switch to the "OFF" position.
2. Add fuel to the fuel tank.
   For filling fuel tank, refer to "Fuel tank oil level - Check" (3-2).
3. Bleed air from the fuel system.
   For bleeding fuel system, refer to "Fuel system (in-line type fuel injection pump) - Bleed air" (8-4) or "Fuel system (distributor type fuel injection pump) - Bleed air" (8-5).
4. Restart the engine.
   For starting the engine, refer to "Starting" (3-4).

Chapter 12 MAIN SPECIFICATIONS

Main specifications

Table 12-1 Main specifications

Item	Specifications	
Engine model	S4S	S4S-DT
Type	Water cooled, 4 stroke cycle diesel engine	4-cycle water-cooled turbocharged diesel engine
No. of cylinders - arrangement	4 cylinder in-line	
Cylinder bore × stroke	φ94 × 120 mm [3.70 x 4.72 in.]	
Displacement	3.331 L [0.9 U.S. gal.]	
Conbustion type	Swirl chamber	Direct injection system
Compression ratio	22 : 1	17 to 19 : 1 (vary among specifications.)
Firing order	1 - 3 - 4 - 2	
Direction of rotation	Counterclockwise as viewed from flywheel side	
Dimensions (L x W x H)	781 × 567 × 717 mm [30.75 x 22.32 x 28.23 in.]	781 × 567 × 815 mm [30.75 x 22.32 x 32.09 in.]
Dry weight	245 kg [540 lbs]	250 kg [551 lbs]
Fuel	Diesel fuel (equivalent for JIS K 2204)	
Fuel injection pump	In-line type or distributor type (VE type)	
Fuel filter	Cartridge type pape-element (with water separator)	
Fuel injection nozzle	Throttle type	Hole type
Initial fuel injection pressure	11.77 MPa {120 kgf/cm^2} [1707 psi]	17.65 MPa {180 kgf/cm^2} [2560 psi]
Lubrication method	Forced circulation (pressure feed by oil pump)	
Lubrication oil	Class CF or CH-4 oil (API service classification)	
Engine oil capacity	Whole engine: Approx. 10 L [2.6 U.S. gal.], Oil pan: Approx. 9 L [2.4 U.S. gal.]	
Oil filter	Cartridge type paper-element	
Oil cooler	-	Water cooled multi-plate (built-in crankcase)
Cooling method	Forced water cooling by centrifugal pump	
Coolant capacity	Approx. 5.5 L [1.5 U.S. gal.] (basic engine only)	Approx. 5 L [1.5 U.S. gal.] (basic engine only)
Starting system	Electric motor starting	
Starter	DC 12 V - 2.2 kW or DC 24 V - 3.2 kW	
Alternator	DC 12 V - 50 A or DC 24 V - 25 A	
Turbocharger	-	Mitsubishi TD04H

Note: (a) The specifications above are subject to change without prior notice.

(b) The specifications above are described for the standard model. The special model specifications may differ from those of standard model.

Table 12-2 Main specifications

Item	Specifications	
Engine model	S6S	S6S-DT
Type	Water cooled, 4 stroke cycle diesel engine	4-cycle water-cooled turbocharged diesel engine
No. of cylinders - arrangement	6 cylinder in-line	
Cylinder bore × stroke	φ94 × 120 mm [3.70 x 4.72 in.]	
Displacement	4.996 L [1.3 U.S. gal.]	
Conbustion type	Swirl chamber	Direct injection system
Compression ratio	22 : 1	17 to 19 : 1 (vary among specifications.)
Firing order	1 - 5 - 3 - 6 - 4 - 2	
Direction of rotation	Counterclockwise as viewed from flywheel side	
Dimensions (L x W x H)	1038 × 567 × 750 mm [40.87 x 22.32 x 29.53 in.]	1038 × 567 × 842 mm [40.87 x 22.32 x 33.15 in.]
Dry weight	345 kg [761 lbs]	355 kg [783 lbs]
Fuel	Diesel fuel (equivalent for JIS K 2204)	
Fuel injection pump	In-line or distributor type (VE type)	
Fuel filter	Cartridge type pape-element (with water separator)	
Fuel injection nozzle	Throttle type	Hole type
Initial fuel injection pressure	11.77 MPa {120 kgf/cm^2} [1707 psi]	17.65 MPa {180 kgf/cm^2} [2560 psi]
Lubrication method	Forced circulation (pressure feed by oil pump)	
Lubrication oil	Class CF or CH-4 oil (API service classification)	
Engine oil capacity	Whole engine: Approx. 12 L [3.2 U.S. gal.], Oil pan: Approx. 11 L [2.9 U.S. gal.]	
Oil filter	Cartridge type paper-element	
Oil cooler	-	Water cooled multi-plate (built-in crankcase)
Cooling method	Forced water cooling by centrifugal pump	
Coolant capacity	Approx. 9 L [2.4 U.S. gal.] (basic engine only)	Approx. 8 L [2.1 U.S. gal.] (basic engine only)
Starting system	Electric motor starting	
Starter	DC 12 V - 3.0 kW or DC 24 V - 5.0 kW	
Alternator	DC 12 V - 50 A or DC 24 V - 25 A	
Turbocharger	-	Mitsubishi TD06H

Note: (a) The specifications above are subject to change without prior notice.

(b) The specifications above are described for the standard model. The special model specification may differ from those of standard model.

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9.2. Appendix B - Alternator user and maintenance manual

User guide and maintenance manual

LEROY SOMER

Alternator

43.2 & 44.2
SHUNT, AREP & PMG

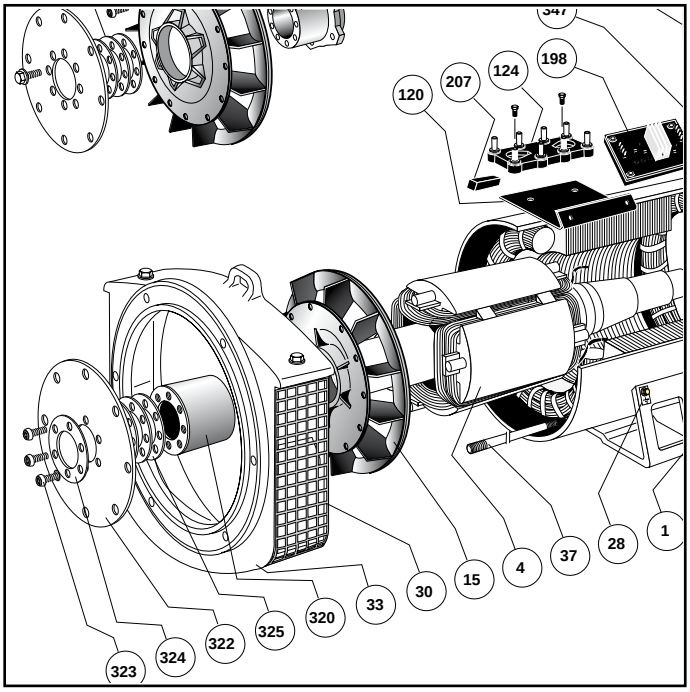
3434 i
01/10/2010

33522059401_6_1

LEROY SOMER

3434 en - 2010 .10 / i

This manual is to be given to the end user



LSA 43.2/44.2 - 4 POLE

ALTERNATORS

Installation and maintenance

LSA 43.2 / 44.2 - 4-POLE

ALTERNATORS

This manual concerns the alternator which you have just purchased.

The latest addition to a whole new generation of alternators, this range benefits from the experience of the world's leading manufacturer, using advanced technology and incorporating strict quality control.

SAFETY MEASURES

Before using your alternator for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this alternator must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional information you may require.

The various operations described in this manual are accompanied by recommendations or symbols to alert the user to potential risk of accident. It is vital that you understand and take notice of the different warning symbols used.

CAUTION

Warning symbol for an operation capable of damaging or destroying the alternator or surrounding equipment.

Warning symbol for general danger to personnel.

Warning symbol for electrical danger to personnel.

Note: LEROY-SOMER reserves the right to modify the characteristics of its products at any time in order to incorporate the latest technological developments. The information contained in this document may therefore be changed without notice.

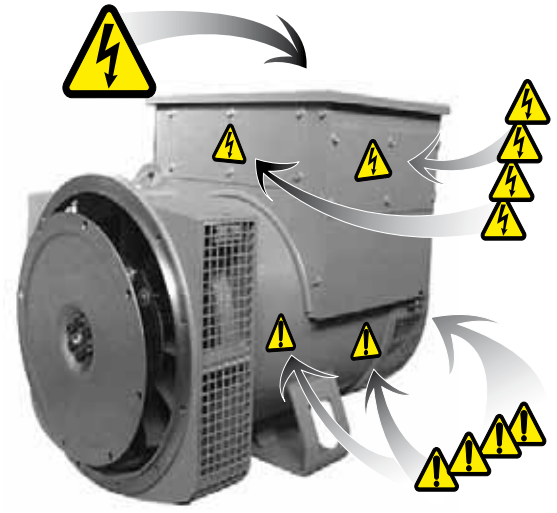
WARNING SYMBOLS

We would like to draw your attention to the following two safety measures that must be complied with:

a) During operation, do not allow anyone to stand in front of the air outlet guards, in case anything is ejected from them.

b) Do not allow children younger than 14 to go near the air outlet guards.

A set of self-adhesive stickers depicting the various warning symbols is included with this maintenance manual. They should be positioned as shown in the drawing below once the alternator has been fully installed.



WARNING

The alternators must not be put into service until the machines in which they are to be incorporated have been declared compliant with Directives EC plus any other directives that may be applicable.

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LSA 43.2 / 44.2 - 4-POLE

ALTERNATORS

1 - RECEIPT

1.1 - Standards and safety measures

Our alternators comply with most international standards.

See the EC Declaration of Incorporation on the last page.

1.2 - Inspection

On receipt of your alternator, check that it has not suffered any damage in transit. If there are obvious signs of knocks, contact the transporter (you may able to claim on their insurance) and after a visual check, turn the machine by hand to detect any malfunction.

1.3 - Identification

The alternator is identified by means of a nameplate glued to the frame.

Make sure that the nameplate on the alternator conforms to your order.

The alternator name is defined according to various criteria (see below).

Example of description: **LSA 43.2 M45 J6/4**

- LSA: Name used in the PARTNER range
- M: Marine
- C: Cogeneration
- T: Telecommunications
- 43.2: Machine type
- M45: Model
- J: Excitation system (C: AREP/J: SHUNT or PMG/ E: COMPOUND)
- 6/4: Winding number/number of poles

1.3.1 - Nameplate

So that you can identify your alternator quickly and accurately, we suggest you fill in its specifications on the non-contractual nameplate below.

1.4 - Storage

Prior to commissioning, machines should not be stored in humid conditions: at relative humidity levels greater than 90%, the machine insulation can drop very rapidly, to just above zero at around 100%. The state of the anti-rust protection on unpainted parts should be monitored.

For storage over an extended period, the alternator can be placed in a sealed enclosure (heatshrunk plastic for example) with dehydrating sachets inside, away from significant and frequent variations in temperature to avoid the risk of condensation during storage.

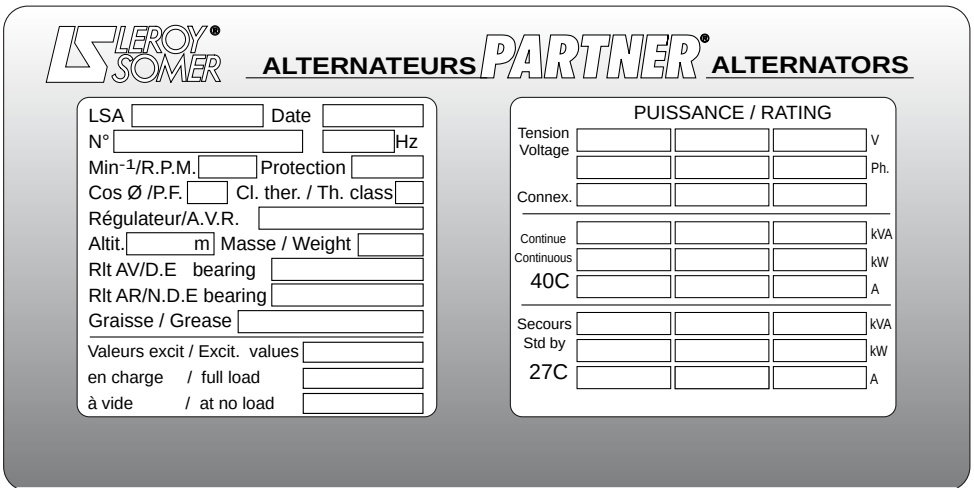
If the area is affected by vibration, try to reduce the effect of these vibrations by placing the generator on a damper support (rubber disc or similar) and turn the rotor a fraction of a turn once a fortnight to avoid marking the bearing rings.

1.5 - Applications

These alternators are designed mainly to produce electricity in the context of applications involving the use of generators.

1.6 - Contra-indications to use

Use of the alternator is restricted to operating conditions (environment, speed, voltage, power, etc.) compatible with the characteristics indicated on your genset.



LSA 43.2 / 44.2 - 4-POLE

ALTERNATORS

2 - TECHNICAL CHARACTERISTICS

2.1 - Electrical characteristics

PARTNER LSA 43.2/44.2 alternators are generators without sliprings or revolving field brushes, wound as «2/3 pitch», 12-wire; the insulation is class H and the field excitation system is available in either «SHUNT», «AREP» or «PMG» versions (see AVR manual).

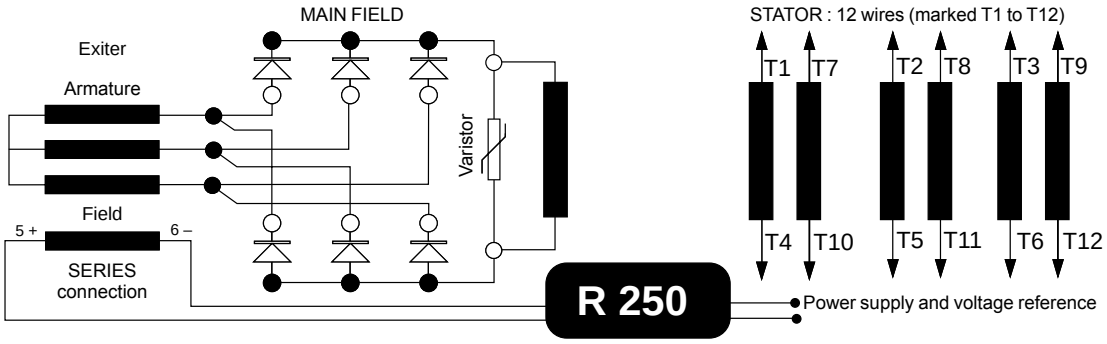
2.1.1 - Options

- Stator temperature detection probes.
- Space heaters.

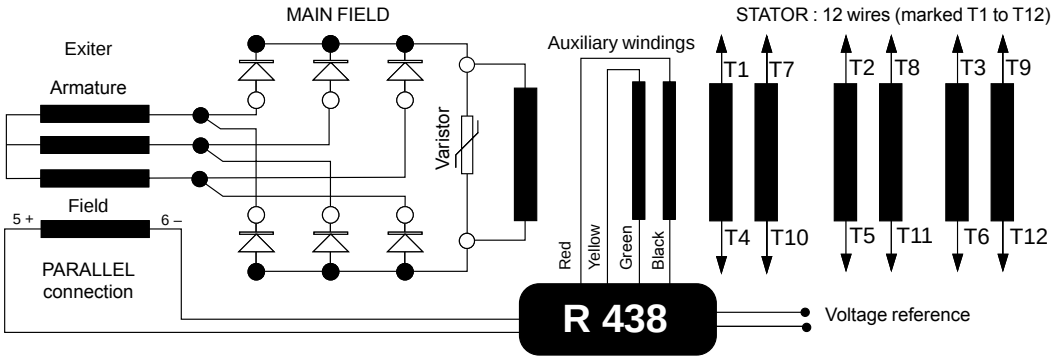
Interference suppression conforms to standard EN 55011, group 1, class B. (Europe).

2.1.2 - SHUNT system with R 250 AVR

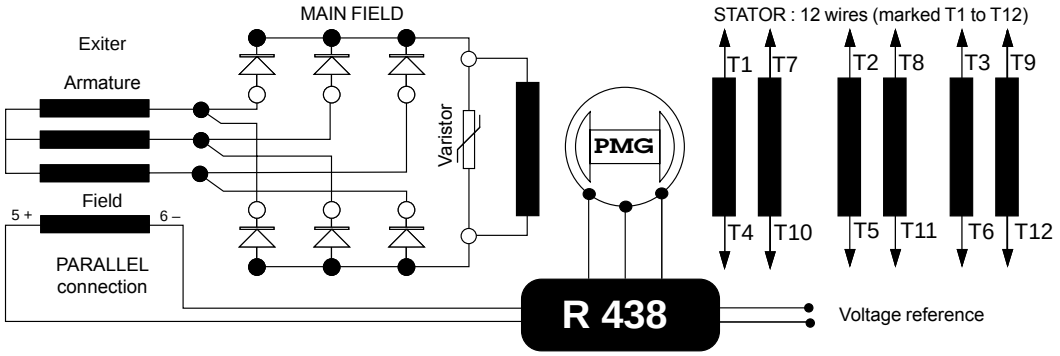
Other version R 251 AVR for dedicated single-phase or R 448 for additional function.



2.1.3 - AREP system with R 438 AVR



2.1.4 - PMG system with R 438 AVR



2.2 - Mechanical characteristics

- Steel frame
- Cast iron end shields
- Protected ball bearings, greased for life
- Mounting arrangements:

IM 1201 (MD 35) foot and flange mounted, single-bearing with SAE coupling disc.
IM 1001 (B 34) double-bearing with SAE flange and standard cylindrical shaft extension.

- Drip-proof machine, self-cooled
- Degree of protection: IP 23

2.2.1 - Options

- Air inlet filter
- Regreasable bearings (only for LSA 44.2 and SHUNT or AREP version)
- IP 44 protection

3 - INSTALLATION

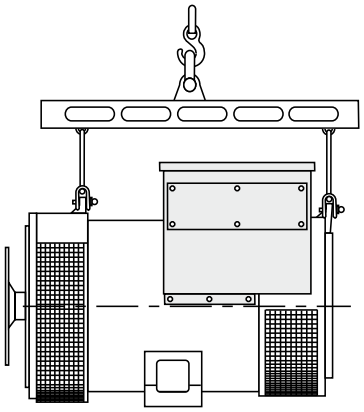
Personnel undertaking the various operations discussed in this section must wear the appropriate personal protective equipment for mechanical and electrical hazards.

3.1 - Assembly

All mechanical handling operations must be undertaken using approved equipment and the machine must be horizontal. Check how much the alternator weight (see 4.9) before choosing the lifting tool. During this operation, do not allow anyone to stand under the load.

3.1.1 - Handling

The generously-sized lifting rings are for handling the alternator alone. They must not be used to lift the genset. The choice of lifting hooks or handles should be determined by the shape of these rings. Choose a lifting system that has regard for the integrity and environment of the alternator.



3.1.2 - Coupling

3.1.2.1 - Single-bearing alternator

Before coupling the alternator and the heat engine, check they are compatible by:

- undertaking a torsional analysis of the transmission on both units
- checking the dimensions of the flywheel and its housing, the flange, coupling discs and offset.

CAUTION

When coupling the alternator to the prime mover, the holes of the coupling discs should be aligned with the flywheel holes by cranking the engine.

Do not use the alternator fan to turn the rotor.

Make sure the alternator is securely bedded in position during coupling.

Tighten the coupling disc screws to the recommended torque and check that there is lateral play on the crankshaft.

3.1.2.2 - Two-bearing alternator

- Semi-flexible coupling

Careful alignment of the alternator and the heat engine is recommended, checking that the differences in concentricity and parallelism of the two parts of the coupling do not exceed 0.1 mm.

CAUTION

This alternator has been balanced with a half-key.

3.1.3 - Location

Ensure that the ambient temperature in the room where the alternator is placed cannot exceed 40 °C for standard power ratings (for temperatures > 40 °C, apply a derating coefficient). Fresh air, free from damp and dust, must be able to circulate freely around the air intake grilles on the opposite side from the coupling.

3.2 - Inspection prior to first use

3.2.1 - Electrical checks

Under no circumstances should an alternator, new or otherwise, be operated if the insulation is less than 1 megohm for the stator and 100,000 ohms for the other windings.

There are three possible methods for restoring the above minimum values.

a) Dry out the machine for 24 hours in a drying oven at a temperature of approximately 110 °C (without the AVR).

b) Blow hot air into the air inlet, having made sure that the machine is rotating with the exciter field disconnected.

c) Run in short-circuit mode (disconnect the AVR):

- Short-circuit the three output terminals (power) using connections capable of supporting the rated current (try not to exceed 6 A/ mm^2)
- Insert a clamp ammeter to monitor the current passing through the short-circuit connections
- Connect a 48 Volt battery in series with a rheostat of approximately 10 ohms (50 W) to the exciter field terminals, respecting the polarity
- Open all the alternator openings fully
- Run the alternator at its rated speed, and adjust the exciter field current using the rheostat to obtain the rated output current in the short-circuit connections

Note: Prolonged standstill: In order to avoid these problems, we recommend the use of space heaters, as well as turning over the machine from time to time. Space heaters are only really effective if they are working continuously while the machine is stopped.

CAUTION

Ensure that the alternator has the degree of protection matching the defined environmental conditions.

LSA 43.2 / 44.2 - 4-POLE

ALTERNATORS

3.2.2 - Mechanical checks

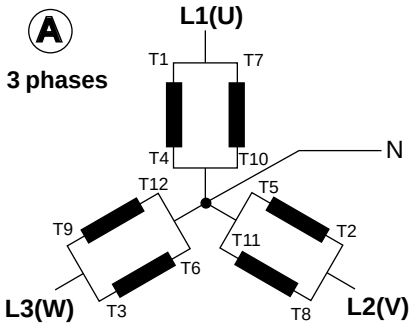
Before starting the machine for the first time, check that:
- the fixing bolts on the feet are tight,
- the cooling air is drawn in freely,
- the protective grilles and housing are correctly in place,
- the standard direction of rotation is clockwise as seen from the shaft end (phase rotation in order 1-2-3). For anti-clockwise rotation, swap 2 and 3.
- the winding connection corresponds to the site operating voltage (see section 3.3).

3.3 - Terminal connection diagrams

To modify the connection, change the position of the terminal cables. The winding code is specified on the nameplate.

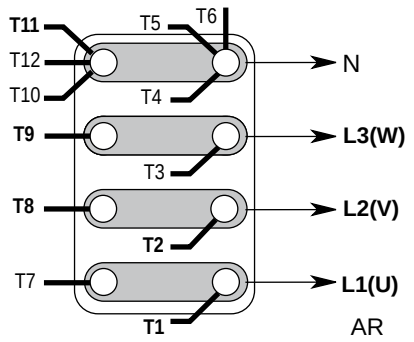
Any intervention on the alternator terminals during reconnection or checks should be performed with the machine stopped.

Connections code A — 3 phases

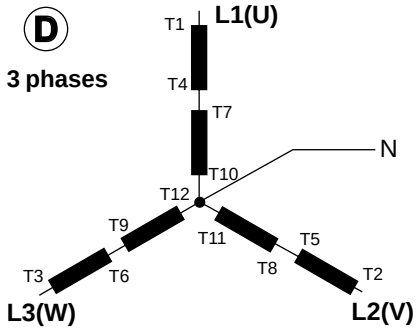


Winding	50 Hz	60 Hz
6	190 - 208	190 - 240
7	220 - 230	-
8	-	190 - 208

R 250 voltage sensing:
0 => (T8) / 110 V => (T11)
R 438 voltage sensing:
0 => (T3) / 220 V => (T2)

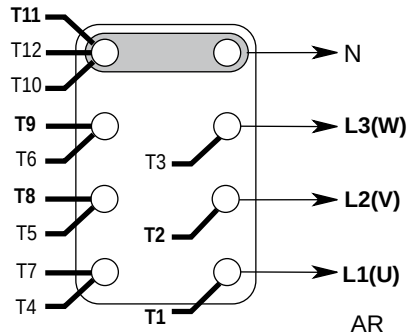


Connections code D — 3 phases

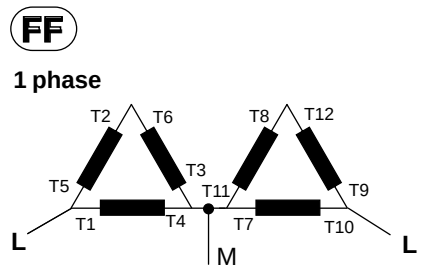


Winding	50 Hz	60 Hz
6	380 - 415	380 - 480
7	440 - 460	-
8	-	380 - 416

R 250 voltage sensing:
0 => (T8) / 110 V => (T11)
R 438 voltage sensing:
0 => (T3) / 380 V => (T2)



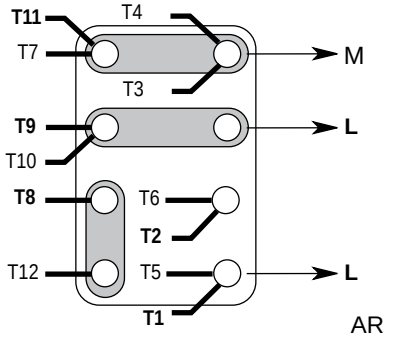
Connections code FF — 1 phase



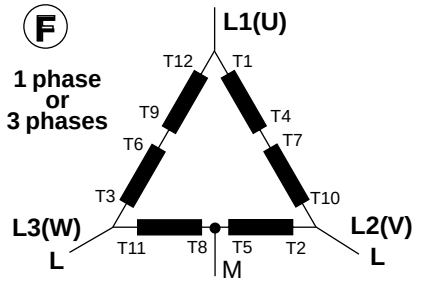
LM voltage = 1/2 LL voltage

Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

R 250 voltage sensing:
0 => (T1) / 110 V => (T4)
R 438 voltage sensing:
0 => (T10) / 220 V => (T1)



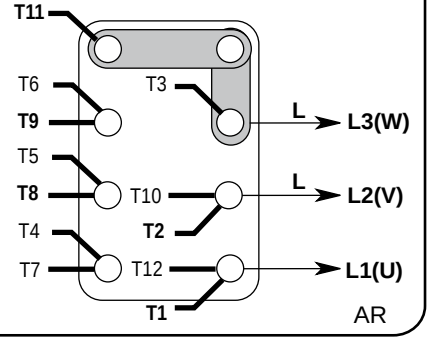
Connections code F — 1 phase or 3 phases



LM voltage = 1/2 LL voltage

Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

R 250 voltage sensing:
0 => (T8) / 110 V => (T11)
R 438 voltage sensing:
0 => (T3) / 220 V => (T2)



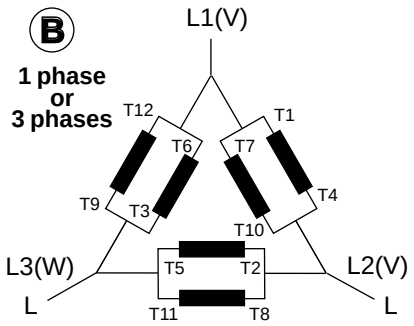
LSA 43.2 / 44.2 - 4-POLE

ALTERNATORS

Connection codes

B

1 phase or 3 phases

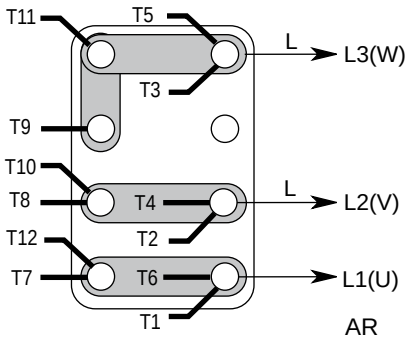


L.L. voltage

Winding	50 Hz	60 Hz
6	110 - 120	120
7	120 - 130	-
8	-	110 - 120

R 250 voltage sensing:
0 => (T8) / 110 V => (T11)
R 438 voltage sensing:
0 => (T3) / 110 V => (T2)

Factory connection

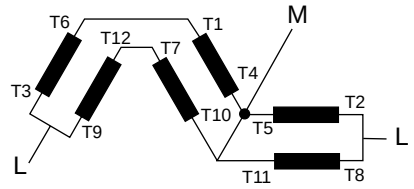


FOR LSA 44.2, THE COUPLING B IS NOT POSSIBLE

G

Connection not recommended

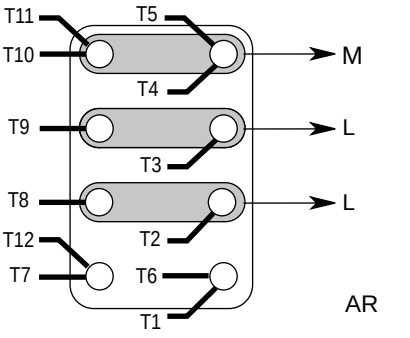
1 phase



LM voltage = 1/2 LL voltage

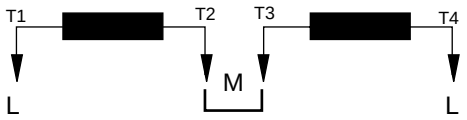
Winding	50 Hz	60 Hz
6	220 - 240	220 - 240
7	250 - 260	-
8	200	220 - 240

R 250 voltage sensing:
0 => (T8) / 110 V => (T11)
R 438 voltage sensing:
0 => (T3) / 220 V => (T2)



SINGLE-PHASE 4-WIRE - type M or M1 DEDICATED WINDING

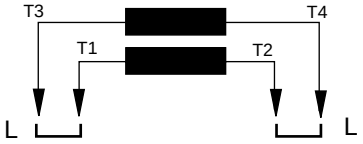
SERIAL CONNECTION



Voltage 50/60Hz			Output		
L - L	L - M	Link	L	L	M
220 230 240	110 115 120	T2 - T3	T1	T4	T2 - T3

R 251 voltage sensing: 0 => (T1) / 110 V => (T2)

PARALLEL CONNECTION (Not possible with LSA 44.2)

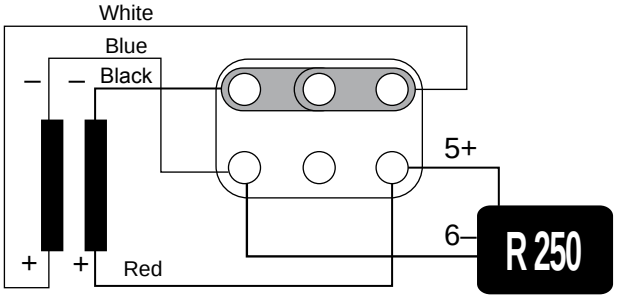


Voltage 50/60Hz			Output		
L - L	L - M	Link	L	L	M
110 115 120	- - -	T1 - T3 T2 - T4	T1-T3	T2 - T4	-

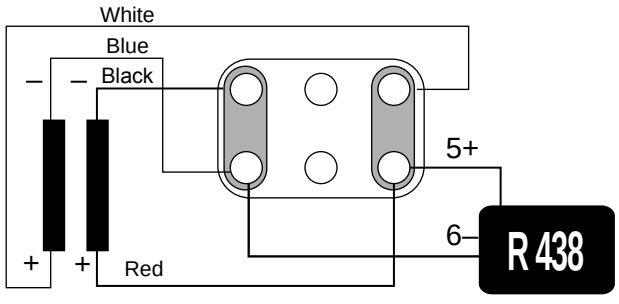
R 251 voltage sensing: 0 => (T1) / 110 V => (T2)

3.3.1 - Connexion de l'excitatrice

Series connection (shunt excitation)

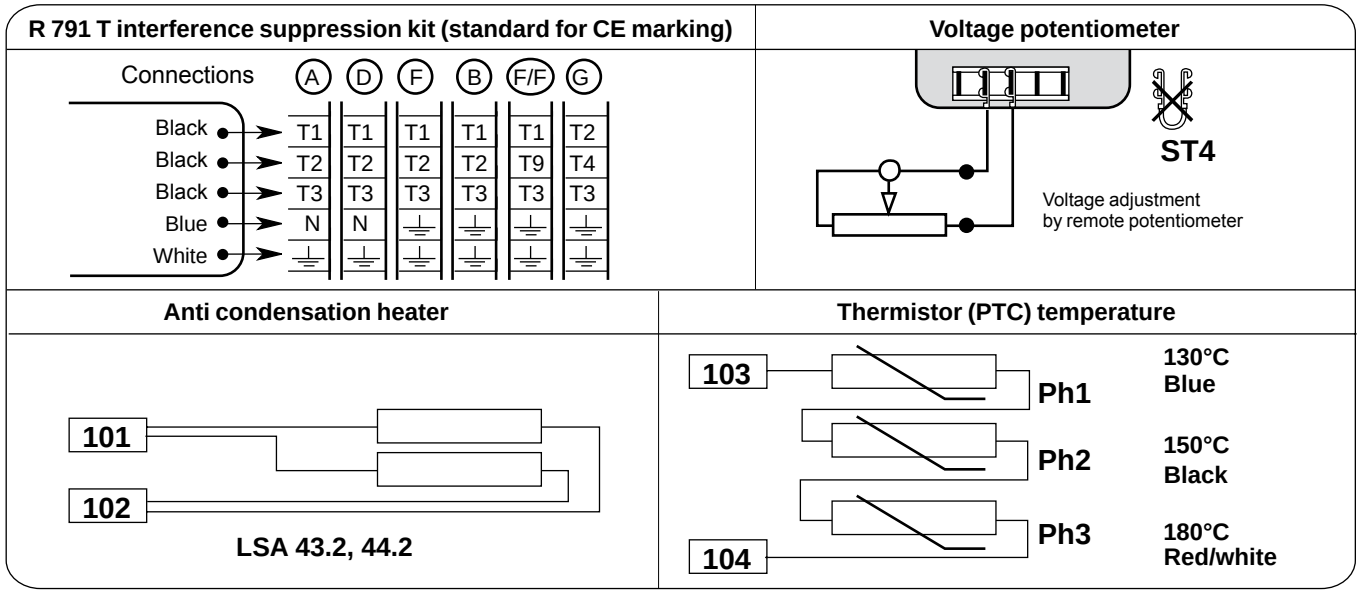


Parallel connection (AREP or PMG excitation)



Single-phase dedicated SHUNT version: R 251 AVR, no connection for 2000 (2-wire output without terminal block)

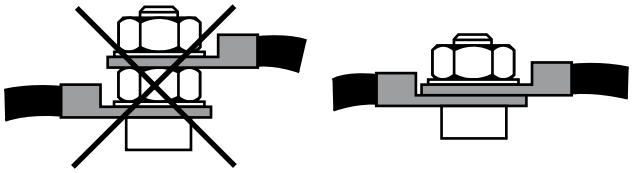
3.3.2 - Schéma de connexion des options



3.3.3 - Connection checks

Electrical installations must comply with the current legislation in force in the country of use.

Check that:
- The residual circuit-breaker complies with legislation on protection of personnel in force in the country of use, and has been correctly installed on the alternator power output as close as possible to the alternator. (In this case, disconnect the blue wire of the R 791 interference suppression module linking the neutral);
- Any protective devices in place have not tripped;
- If there is an external AVR, the connections between the alternator and the cubicle are made in accordance with the connection diagram;
- There is no short-circuit between phase or phase-neutral between the alternator output terminals and the generator set control cabinet (part of the circuit not protected by circuit-breakers or cubicle relays);
- The alternator has been connected with the busbar separating the terminals as shown in the terminal connection diagram.



- The equipotential earth links have been implemented correctly (cross-section and continuity of the earths).

3.4 - Commissioning

The alternator can only be started up and used if the installation is in accordance with the regulations and instructions defined in this manual.

The alternator is tested and set in the factory. When first used with no load, make sure that the drive speed is correct and stable (see the genset nameplate). On application of the load, the alternator should achieve its rated speed and voltage; however, in the event of abnormal operation, the alternator setting can be altered (follow the adjustment procedure: see section 3.5). If the operation is still incorrect, the cause of the malfunction must be located (see section 4.4 & 4.5).

3.5 - Setting up

The various adjustments during tests must be made by a qualified engineer. The screwdriver for making adjustments must be suitable for use with electrical equipment. It is essential that the drive speed specified on the genset nameplate is reached before commencing adjustment. The AVR is used to make any adjustments to the alternator. Access to the AVR adjustments is via the panel provided for this purpose.
After operational testing, replace all access panels or covers.

4 - SERVICING / MAINTENANCE

4.1 - Safety measures

Servicing or troubleshooting must be carried out strictly in accordance with instructions so as to avoid the risk of accidents and to maintain the alternator in its original state.

All such operations performed on the alternator should be undertaken by personnel trained in the commissioning, servicing and maintenance of electrical and mechanical components, who must wear the appropriate personal protective equipment for mechanical and electrical hazards.
Before carrying out any work on the alternator, ensure that it cannot be started by a manual or automatic system by isolating the power in any cabinet or enclosure and make sure you have understood the operating principles of the system.

4.2 - Regular maintenance

4.2.1 - Checks after start-up

After approximately 20 hours of operation, check that all fixing screws on the alternator are still tight, plus the general state of the alternator and the various electrical connections in the installation.

4.2.2 - Cooling circuit

It is advisable to check that circulation of air is not reduced by partial blocking of the air intake and outlet grilles: mud, fibre, grease, etc. and to check whether the ventilation guards are corroded or scratched.

4.2.3 - Bearings

The bearings are permanently greased: approximate life of the grease = 20,000 hours or 3 years.
As an option, they are regreasable for the LSA 44.2. It is advisable to lubricate the alternator during operation. Time intervals and quantity of grease are given in the table below.

NDE/DE bearing	6315 C3	6309 C3
Quantity of grease	30 g	15 g
Regreasing interval	6000 hrs	10,000 hrs

Lubrication intervals are given for grease type
LITHIUM - standard - NLGI 3.
In the factory, the grease used for lubrication is:
ESSO UNIREX N3.
Before using another grease, check for compatibility with the original one. Monitor the temperature rise in the bearings, which must not exceed 50°C above the ambient temperature. Should this value be exceeded, the alternator must be stopped and checks carried out.

4.2.4 - Electrical servicing

Cleaning product for the windings.

CAUTION

Do not use: trichlorethylene, perchlorethylene, trichloroethane or any alkaline products.

Certain strictly defined pure volatile degreasing agents can be used, such as:
- Normal petrol (without additives); inflammable
- Toluene (slightly toxic); inflammable
- Benzene (or benzine, toxic); inflammable
- Ciclohexare (non toxic); inflammable

The insulating components and the impregnation system are not at risk of damage from solvents (see the list of authorized products).
Avoid letting the cleaning product run into the slots. Apply the product with a brush, sponging frequently to avoid accumulation in the housing. Dry the winding with a dry cloth. Let any traces evaporate before reassembling the alternator.

These operations must be performed at a cleaning station, equipped with a vacuum system that collects and flushes out the products used.

4.2.5 - Mechanical servicing

CAUTION

Cleaning the machine using a water spray or a high-pressure washer is strictly prohibited.
Any problems arising from such treatment are not covered by our warranty.
The machine should be cleaned with a degreasing agent, applied using a brush. Check that the degreasing agent will not affect the paint.
Compressed air should used to remove any dust.
If filters have been added to the machine after manufacture and do not have thermal protection, the service personnel should clean the air filters periodically and systematically, as often as necessary (every day in very dusty atmospheres).
Cleaning can be performed using water for dry dust or in a bath containing soap or detergent in the case of greasy dust. Petrol or chloroethylene can also be used.
After cleaning the alternator, it is essential to check the winding insulation (see sections 3.2 and 4.8).

4.3 - Fault detection

If, when commissioned, the alternator does not work normally, the source of the malfunction must be identified.
To do this, check that:
- the protective devices are fitted correctly
- the connections comply with the diagrams in the manuals supplied with the machine
- the speed of the unit is correct (see section 1.3)
Repeat the operations defined in section 3

4.4 - Mechanical defects

Fault		Action
Bearing	Excessive overheating of one or both bearings (temperature > 80 °C on the bearing retainers with or without abnormal noise)	- If the bearing has turned blue or if the grease has turned black, change the bearing. - Bearing not properly seated. - End shields misaligned (flanges not properly fitted).
Temperature abnormal	Excessive overheating of alternator frame (more than 40 °C above the ambient temperature)	- Air flow (intake-outlet) partially clogged or hot air is being recycled from the alternator or engine - Alternator operating at too high a voltage (> 105% of Un on load) - Alternator overloaded
Vibration	Excessive vibration	- Misalignment (coupling) - Defective mounting or play in coupling - Rotor balancing fault
	Excessive vibration and humming noise coming from the machine	- Alternator operating in single-phase mode (single-phase load or faulty contactor or installation fault) - Stator short-circuit
Abnormal noise	Alternator damaged by a significant impact, followed by humming and vibration	- System short-circuit - Mis-paralleling Possible consequences - Broken or damaged coupling - Broken or bent shaft end - Shifting and short-circuit of main field - Fan fractured or coming loose on shaft - Irreparable damage to rotating diodes or AVR

4.5 - Electrical faults

Fault	Action	Effect	Check/Cause
No voltage at no load on start-up	Connect between E- and E+ a new battery of 4 to 12 volts, respecting the AVR polarities, for 2 to 3 seconds	The alternator builds up and its voltage is still correct when the battery is removed.	- Lack of residual magnetism
		The alternator builds up but its voltage does not reach the rated value when the battery is removed.	- Check the connection of the voltage reference to the AVR - Faulty diodes - Armature short-circuit
		The alternator builds up but its voltage disappears when the battery is removed	- Faulty AVR - Field windings disconnected - Main field winding open circuit. Check the resistance
Voltage too low	Check the drive speed	Correct speed	Check the AVR connections (AVR may be faulty) - Field windings short-circuited - Rotating diodes burnt out - Main field winding short-circuited - Check the resistance
		Speed too low	Increase the drive speed (Do not touch the AVR voltage pot. (P2) before running at the correct speed.)
Voltage too high	Adjust AVR voltage potentiometer	Adjustment ineffective	Faulty AVR
Voltage oscillations	Adjust AVR stability potentiometer	If no effect: try normal/rapid recovery modes (ST2)	- Check the speed: possibility of cyclic irregularity - Loose connections - Faulty AVR - Speed too low when on load (or LAM set too high)
Voltage correct at no load and too low when on load (*)	Run at no load and check the voltage between E+ and E- on the AVR	Voltage between E+ and E- SHUNT < 20 V - AREP/PMG < 10 V	- Check the speed (or LAM set too high)
		Voltage between E+ and E- SHUNT > 30 V - AREP/PMG > 15 V	- Faulty rotating diodes - Short-circuit in the main field. Check the resistance - Faulty exciter armature
(*) Caution: For single-phase operation, check that the sensing wires coming from the AVR are correctly connected to the operating terminals			
Voltage disappears during operation (**)	Check the AVR, the surge suppressor, the rotating diodes, and replace any defective components	The voltage does not return to the rated value	- Exciter winding open circuit - Faulty exciter armature - Faulty AVR - Main field open circuit or short-circuited
(**) Caution: Internal protection may be activated (overload, open circuit, short-circuit)			

4.5.1 - Checking the winding

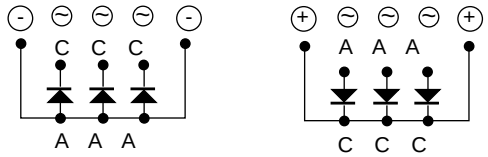
You can check the winding insulation by performing a high voltage test. In this case, you must disconnect all AVR wires.

CAUTION

Damage caused to the AVR in such conditions is not covered by our warranty.

4.5.2 - Checking the diode bridge

LSA 43.2 / 44.2 diode bridge



A diode in good working condition allows the current to flow in only one direction, from anode to cathode.

4.5.3 - Checking the windings and rotating diodes using separate excitation

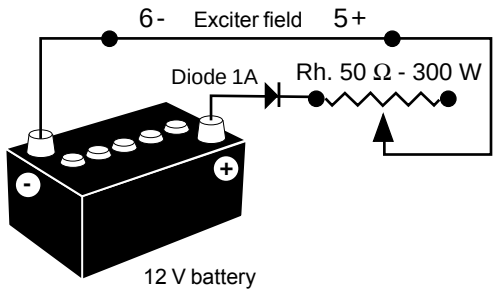
During this procedure, make sure that the alternator is disconnected from any external load and inspect the terminal box to check that the connections are fully tightened.

1) Stop the unit, disconnect and isolate the AVR wires.

2) There are two ways of creating an assembly with separate excitation.

Assembly A: Connect a 12 V battery in series with a rheostat of approximately 50 ohms - 300 W and a diode on both exciter field wires (5+) and (6-).

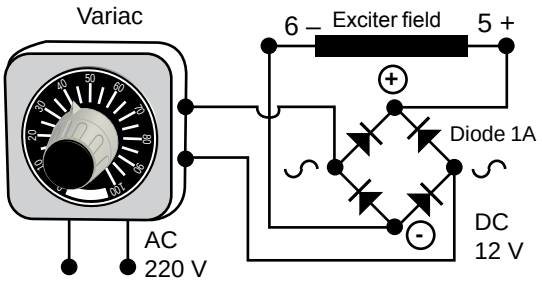
Assembly A



Assembly B: Connect a «Variac» variable power supply and a diode bridge on both exciter field wires (5+) and (6-).
Both these systems should have characteristics which are compatible with the field excitation power of the machine (see the genset nameplate).

3) Run the unit at its rated speed.

4) Gradually increase the exciter field supply current by adjusting the rheostat or the Variac and measure the output voltages on L1 - L2 - L3, checking the excitation voltage at no load (see machine nameplate or ask for the factory test report).
When the output voltage is at its rated value and balanced within 1% for the rated excitation level, the machine is in good working order. The fault therefore comes from the AVR or its associated wiring (ie. sensing, auxiliary windings).



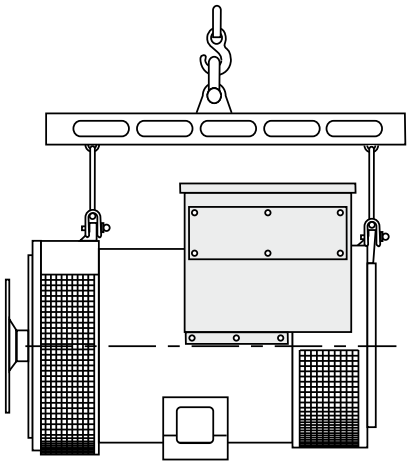
Assembly B

4.6 - Dismantling, reassembly

(see sections 5.4.1/5.4.2 & 5.4.3)

During the warranty period, this operation should only be carried out in an LEROY-SOMER approved workshop or in our factory, otherwise the warranty may be invalidated.

Whilst being handled, the alternator should remain horizontal (translational movement of rotor not locked). Check how much the alternator weighs (see section 4.9) before choosing the lifting method.
The choice of lifting hooks or handles should be determined by the shape of the lifting rings.



4.6.1 - Tools required

To fully dismantle the machine, we recommend using the tools listed below:
- 1 ratchet spanner + extension
- 1 torque wrench
- 1 set of flat spanners: 7 mm, 8 mm, 10 mm, 12 mm
- 1 socket set: 8 mm, 10 mm, 13 mm, 16 mm, 18 mm, 21 mm, 22 mm, 24 mm
- 1 size 5 Allen key (eg. Facom: ET5)
- 1 size 6 Allen key (eg. Facom: ET6)
- 1 size 10 Allen key (eg. Facom: ET10)
- 1 size 14 Allen key (eg. Facom: ET14)
- 1 T20 and T30 TORX bit
- 1 puller (eg. Facom: U35)
- 1 puller (eg. Facom: U32/350).

4.6.2 - Screw tightening torque

IDENTIFICATION	screw Ø	Torque N.m
Field terminal block screw	M4	4 N.m
Field screw	M6	10 N.m
Diode bridge/RP	M6	5 N.m
Diode nut	M5	4 N.m
43.2 tie rod	M12	57 N.m
44.2 tie rod	M14	90 N.m
Earth screw	M8	26 N.m
43.2 disc/shaft screw	M12	110 N.m
44.2 disc/shaft screw	M16	250 N.m
44.2 turbine screw	M6	5 N.m
Grille screws	M6	5 N.m
Cover screws	M6	5 N.m
Terminal block nut	M10	20 N.m

4.6.3 - Access to connections and the regulation system

The terminals are accessed directly by removing the terminal box lid [48].
To access the AVR adjustment potentiometers, the side plate [367] should be removed.

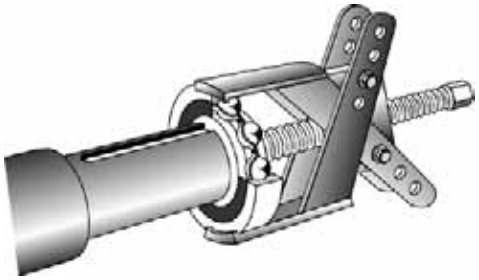
4.6.4 - Accessing, checking and replacing diodes

4.6.4.1 - Dismantling
- Remove the air intake grille [51]
- Remove the surge suppressor [347]
- Disconnect the 6 diodes using an ohmmeter or a battery lamp (see section 4.5.2)

4.6.4.2 - Reassembly
- Replace the bridges, respecting the polarity (see section 4.5.1)
- Replace the surge suppressor [347]
- Refit the air intake grille [51]
- Replace the terminal box lid [48]

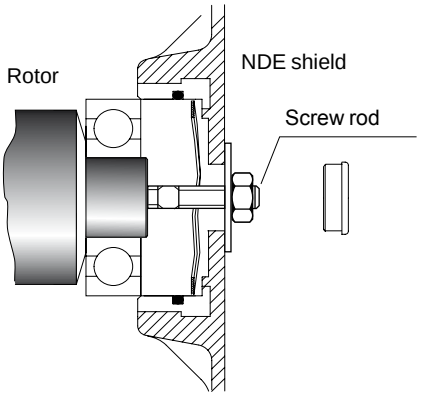
4.6.5 - Replacing the NDE bearing on single-bearing machines

4.6.5.1 - Dismantling
- Remove the terminal box lid [48]
- Remove the air intake grille [51]
- Unscrew the fixing clamps on the power output cables, remove the connector from the exciter and the R 791 module.
- Remove the 4 nuts on the tie rods
- Remove the NDE shield [36] using a puller: eg. U.32 - 350 (FACOM)
- Remove the ball bearing [70] using a screw puller



4.6.5.2 - Reassembly
- Heat the inner slipring of a new bearing by induction or in a drying oven at 80 °C (do not use an oil-bath) and fit it to the machine.
- Place the preloading wavy washer [79] in the shield and fit a new O ring seal [349].

Refit the NDE shield and pass the bundle of wires between the top bars of the shield.
- Refit the fixing clamps on the cables, the R 791 module and the exciter connector.
- Refit the air intake grille [51].
- Replace the terminal box lid [48].



4.6.6 - Replacing the bearings on two-bearing machines

4.6.6.1 - Dismantling
- Uncouple the alternator from the prime mover.
- Remove the 8 assembly screws.
- Remove the DE shield [30].
- Remove the NDE shield (see section 4.6.5.1)
- Remove both ball bearings [60] and [70] using a puller with a central screw.

4.6.6.2 - Reassembly
- Heat the new bearings by induction or in a drying oven at 80°C (do not use an oil-bath) and fit them to the machine.
- Check that both the preloading wavy washer [79] and the new O ring seal [349] have been fitted on the NDE shield [36].

Refit the NDE shield and pass the bundle of wires between the top bars of the shield.
- Refit the DE shield [30] and tighten the 4 fixing screws.
- Check that the machine assembly is correctly mounted and that all screws are tightened.

4.4.6.7 - Accessing the main field and stator

4.6.7.1 - Dismantling

Follow the procedure for dismantling the bearings (see sections 4.6.5.1 and 4.6.6.1)

- Remove the coupling disc (single-bearing alternator) or the DE shield (two-bearing alternator) and insert a tube of the corresponding diameter on the shaft end.
- Rest the rotor on one of its poles, then slide it out. Use the tube as a lever arm to assist dismantling.
- After extraction of the rotor, be careful not to damage the fan. If the fan is dismantled, it is essential that it is replaced for the 43.2.

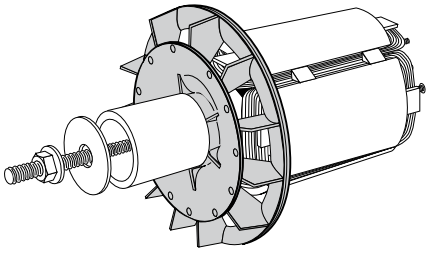
NOTE: If intervention is required on the main field (rewinding, replacement of components), the rotor assembly must be rebalanced.

4.6.7.2 - Reassembling the main field

- Follow the dismantling procedure in reverse order.

Take care not to knock the windings when refitting the rotor in the stator.

- If the fan is being replaced on the 43.2, assemble the parts as shown in the following diagram. Fit a tube and a threaded screw. On the 44.2 the fan is fixed by screws on the hub.



Follow the procedure for reassembling the bearings (see sections 4.6.5.2 and 4.6.6.2).

After operational testing, replace all access panels or covers.

4.7 - Installation and maintenance of the PMG

For the LSA 43.2 and LSA 44.2, the PMG reference is PMG 1. See the PMG maintenance manual, ref: 4211.

CAUTION

Mounting is impossible with the «regreasable bearings» option with the LSA 44.2.

4.8 - Electrical characteristics

Table of average values:
Alternator - 2 and 4 poles - 50 Hz/60 Hz - Winding n° 6 and M or M1 connected in dedicated single-phase. (400 V for the excitation values).
The voltage and current values are given for no-load operation and operation at rated load with separate field excitation. All values are given at ± 10% (for exact values, consult the test report) and are subject to change without prior warning. For 60 Hz machines, the resistance values are the same and the excitation current «i exc» is approximately 5 to 10% weaker.

4.8.1 - 3-phase LSA 43.2 4 P, SHUNT excitation

Resistances at 20 °C (Ω)

LSA 43.2	Stator L/N	Rotor	Field	Armature
S1	0.155	1.35	18.4	0.23
S15	0.155	1.35	18.4	0.23
S25	0.155	1.35	18.4	0.23
S35	0.128	1.41	18.4	0.23
M45	0.105	1.57	18.4	0.23
L65	0.083	1.76	18.4	0.23
L8	0.063	1.96	18.4	0.23

Field excitation current i exc (A) - 400 V - 50 Hz
«i exc»: excitation current of the exciter field

LSA 43.2	no load	on load
S1	0.5	1.3
S15	0.5	1.5
S25	0.5	1.6
S35	0.5	1.8
M45	0.4	1.6
L65	0.4	1.6
L8	0.4	1.6

4.8.2 - 3-phase LSA 43.2 4 P, AREP excitation

Resistances at 20 °C (Ω)

LSA 43.2	Stator L/N	Rotor	Wind. X1,X2	Widing. Z1,Z2	Field	Armat.
S1	0.155	1.35	0.32	0.52	4.6	0.23
S15	0.155	1.35	0.32	0.52	4.6	0.23
S25	0.155	1.35	0.32	0.52	4.6	0.23
S35	0.128	1.41	0.29	0.5	4.6	0.23
M45	0.105	1.57	0.26	0.51	4.6	0.23
L65	0.083	1.76	0.26	0.44	4.6	0.23
L8	0.063	1.96	0.21	0.4	4.6	0.23

Field excitation current i exc (A) -400 V -50 Hz
«i exc»: excitation current of the exciter field

LSA 43.2	no load	on load
S1	1	2.6
S15	1	3
S25	1	3.2
S35	1	3.6
M45	0.8	3.2
L65	0.8	3.2
L8	0.8	3.2

4.8.3 - Dedicated single-phase LSA 43.2: 4-pole, SHUNT excitation (60 Hz only)

Resistances at 20 °C (Ω)

LSA 43.2	Stator L/N	Rotor	Field	Armature
S1	0.058	1.35	13.9	0.23
S25	0.058	1.35	13.9	0.23
S35	0.046	1.41	13.9	0.23
M45	0.037	1.57	13.9	0.23
L65	0.027	1.76	13.9	0.23
L8	0.019	1.96	13.9	0.23

Field excitation current i exc (A) -240 V -60 Hz

«i exc»: excitation current of the exciter field

LSA 43.2	no load	on load
S1	0.59	1.44
S25	0.59	1.68
S35	0.66	1.65
M45	0.61	1.48
L65	0.62	1.48
L8	0.74	1.46

4.8.4 - 3-phase LSA 44.2: 4-pole, SHUNT excitation

Resistances at 20 °C (Ω)

LSA 44.2	Stator L/N	Rotor	Field	Armature
VS3	0.046	2.51	18.4	0.5
VS45	0.046	2.51	18.4	0.5
S7	0.036	2.91	18.4	0.5
S75	0.036	2.91	18.4	0.5
M95	0.024	3.32	18.4	0.5
L12	0.019	3.66	18.4	0.5

Field excitation current i exc (A) - 400 V - 50 Hz

«i exc»: excitation current of the exciter field

LSA 44.2	no load	on load
VS3	0.5	1.8
VS45	0.5	2.1
S7	0.5	1.9
S75	0.5	2.1
M95	0.6	2
L12	0.5	1.9

4.8.5 - 3-phase LSA 44.2: 4-pole, AREP excitation

Resistances at 20 °C (Ω)

LSA 44.2	Stator L/N	Rotor	Wind. X1,X2	Wind. Z1,Z2	Field	Armat.
VS3	0.046	2.51	0.3	0.5	4.9	0.5
VS45	0.046	2.51	0.3	0.5	4.9	0.5
S7	0.036	2.91	0.21	0.32	4.9	0.5
S75	0.036	2.91	0.21	0.32	4.9	0.5
M95	0.024	3.32	0.17	0.28	4.9	0.5
L12	0.019	3.66	0.16	0.21	4.9	0.5

Field excitation current i exc (A) -400 V -50 Hz

«i exc»: excitation current of the exciter field

LSA 44.2	no load	on load
VS3	1	3.6
VS45	1	4.2
S7	1	3.8
S75	1	4.2
M95	1.2	4
L12	1	3.8

4.8.6 - Dedicated single-phase LSA 44.2: 4-pole, SHUNT excitation (60 Hz only)

Resistances at 20 °C (Ω)

LSA 44.2	Stator L/N	Rotor	Field	Armature
VS3	0.0194	2.51	18.4	0.5
VS45	0.0194	2.51	18.4	0.5
S7	0.0140	2.91	18.4	0.5
M95	0.0088	3.32	18.4	0.5

Field excitation current i exc (A) -240 V -60 Hz

«i exc»: excitation current of the exciter field

LSA 44.2	no load	on load
VS3	0.44	1.18
VS45	0.44	1.25
S7	0.43	1.2
M95	0.55	1.28

4.9 - Table of weights

LSA 43.2	Total weight (kg)	Rotor (kg)
S1	220	76
S15	220	76
S25	220	76
S35	240	80
M45	270	90
L65	290	102
L8	330	120

LSA 44.2	Total weight (kg)	Rotor (kg)
VS3	405	140
VS45	405	140
S7	460	165
S75	460	165
M95	515	185
L12	570	210

5 - SPARE PARTS

5.1 - First maintenance parts

Emergency repair kits are available as an option.
They contain the following items:

Ref.	Designation	Qty	LSA 43.2/44.2 - SHUNT	Code
198	AVR	1	R 250	AEM 110 RE 019
			R 251	AEM 110 RE 021
343	Diode bridge assembly	1	LSA 432 9 100	ALT 432 KD 001
347	Surge suppressor	1	LSA 432 1 13	AEM 000 RE 126
	AVR fuse	1	250 V - 8 A/slow-blow	

Ref.	Designation	Qty	LSA 43.2/44.2 - AREP 4 P	Code
198	AVR	1	R 438	AEM 110 RE 017
343	Diode bridge assembly	1	LSA 432 9 100	ALT 432 KD 001
347	Surge suppressor	1	LSA 432 1 13	AEM 000 RE 126
	AVR fuse	2	250 V - 8 A/fast-blow	

5.2 - Bearing designations

Ref.	Designation	Qty	LSA 43.2	Code	LSA 44.2	Code
60	Bearing on shaft extension end	1	6312 2RS/C3	RLT060ET007	6315 2RS/C3	RLT075ET004
70	Bearing on exciter end	1	6307 2RS/C3	RLT035ET030	6309 2RS/C3	RLT045ET030

5.3 - Technical support service

Our technical support service will be pleased to provide any additional information you may require.
When ordering spare parts, you should indicate the complete machine type, its serial number and the information given on the genset nameplate.

Address your enquiry to your usual contact.

CAUTION

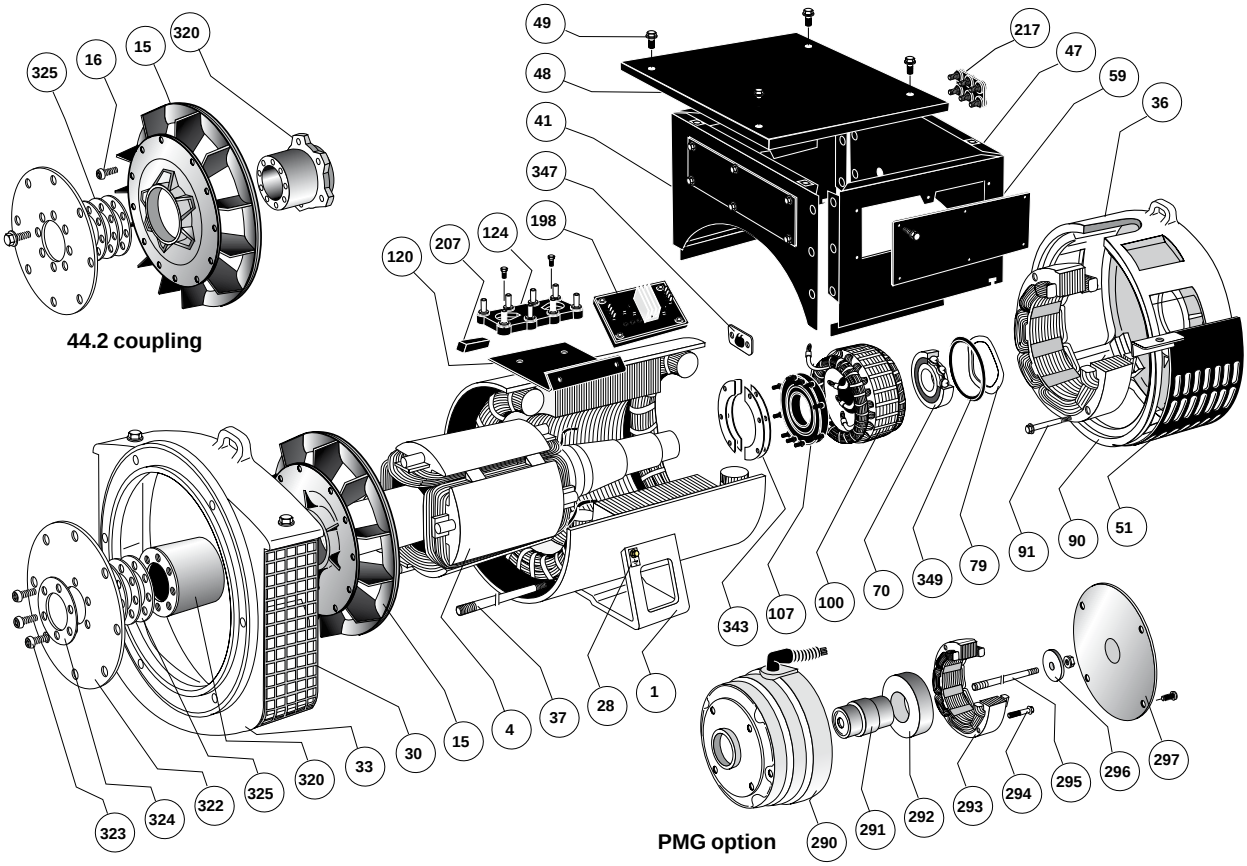
Part numbers should be identified from the exploded views and their description from the parts list.
Our extensive network of service centres can dispatch the necessary parts without delay.
To ensure correct operation and the safety of our machines, we recommend the use of original manufacturer spare parts.
In the event of failure to comply with this advice, the manufacturer cannot be held responsible for any damage.

LSA 43.2 / 44.2 - 4-POLE

ALTERNATORS

5.4 - Exploded views, parts list

5.4.1 - Single-bearing LSA 43.2/44.2

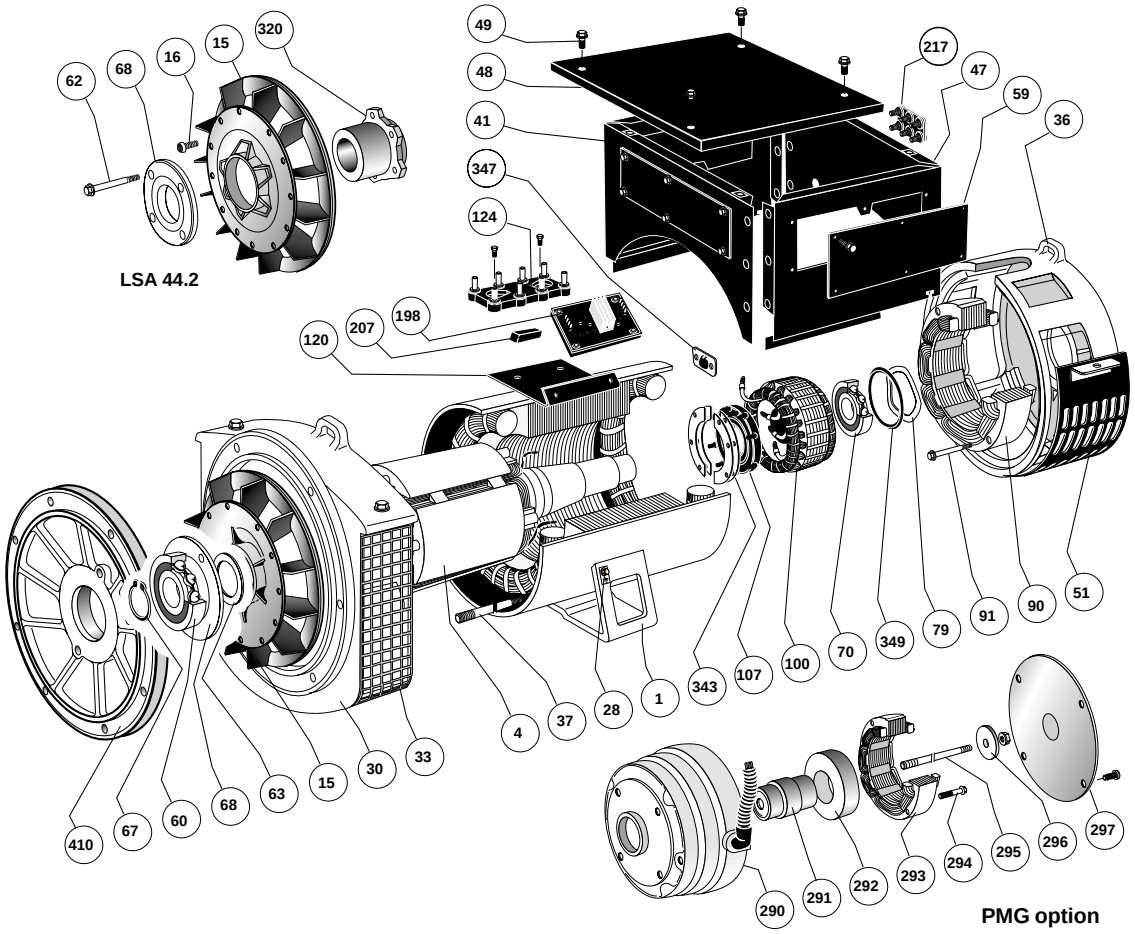


N°	Nbr	Description	N°	Nbr	Description
1	1	Stator assembly	120	1	Terminal block support (AREP)
4	1	Rotor assembly	124	1	Terminal block
15	1	Fan	198	1	Voltage regulator (AVR)
16	6	Fixing screws (44.2 only)	207	1	AVR damper seal
28	1	Earth terminal	217	1	Terminal block
30	1	DE shield	290	1	PMG housing
33	1	Air outlet grille	291	1	Adaptation shaft
36	1	Shield on exciter end	292	1	Magnetic rotor
37	4	Tie rod	293	1	Stator
41	1	Cover front panel	294	2	Fixing screws
47	1	Cover rear panel	295	1	Tie rod
48	1	Cover top panel	296	1	Cable gland washer + nut
49	34	Fixing screws	297	1	End plate
51	1	Air intake grille	320	1	Hub (43.2 L7 & 44.2 only)
59	3	Inspection door	322	1	Coupling disc
70	1	NDE bearing	323	-	Fixing screws
79	1	Preloading wavy washer	324	1	Clamping washer (43.2 S1 to L6)
90	1	Exciter field	325	-	Spacer shim (43.2 L7 & 44.2 only)
91	4	Exciter field fixing screw	343	1	Diode bridge assembly
100	1	Exciter armature	347	1	Surge suppressor
107	1	Diode crescent support	349	1	«O» ring

LSA 43.2 / 44.2 - 4-POLE

ALTERNATORS

5.4.2 - Two-bearing LSA 43.2/44.2



N°	Nbr	Description	N°	Nbr	Description
1	1	Stator assembly	90	1	Exciter field
4	1	Rotor assembly	91	4	Exciter field fixing screw
15	1	Fan	100	1	Exciter armature
16	6	Fixing screws (44.2 only)	107	1	Diode crescent support
28	1	Earth terminal	120	1	Terminal block support (AREP)
30	1	DE shield	124	1	Terminal block
33	1	Air outlet grille	198	1	Voltage regulator (AVR)
36	1	Shield on exciter end	207	1	AVR damper seal
37	4	Tie rod	217	1	Terminal block
41	1	Cover front panel	290	1	PMG housing
47	1	Cover rear panel	291	1	Adaptation shaft
48	1	Cover top panel	292	1	Magnetic rotor
49	34	Fixing screws	293	1	Stator
51	1	Air intake grille	294	2	Fixing screws
59	3	Inspection door	295	1	Tie rod
60	1	DE bearing	296	1	Cable gland washer + nut
62	2/4	Bearing retainer fixing screw	297	1	End plate
63	1	Cable gland washer (43.2 only)	320	1	Hub (44.2 only)
67	1	Circlips	343	1	Diode bridge assembly
68	1	Inner bearing retainer	347	1	Surge suppressor
70	1	NDE bearing	349	1	«O» ring
79	1	Preloading wavy washer	410	1	End shield

Electric Power Generation

DECLARATION of COMPLIANCE
related to CE marking

This Declaration applies to the generators designed to be incorporated into machines complying with the Machine Directive Nr 2006/42/CE dated 17 May 2006.

MOTEURS LEROY-SOMER
Boulevard Marcellin Leroy
16015 ANGOULEME (France)

Declares hereby that the electric generators of the ranges " PARTNER", Industrial and Professional, as well as their derivatives, manufactured by Leroy Somer or on Leroy Somer's behalf, comply with the following International Standards and Directives :

- EN et CEI 60034 -1 et 60034 -5
- ISO 8528 – 3 " Reciprocating internal combustion engine driven alternating current generating sets. Part 3. Alternating current generators for generating sets "
- The Low Voltage Directive Nr 2006/95/CE dated 12 December 2006.

Furthermore, these generators, designed in compliance with the Machine Directive Nr 2006/42, are therefore able to be incorporated into Electrical Gen-Sets complying with the following International Standards and Directives :

- The Machine Directive Nr 2006/42/CE dated 17 May 2006
- The EMC Directive Nr 2004/108/CE dated 15 December 2004, as intrinsic levels of emissions and immunity are concerned

WARNING :

The here above mentioned generators should not be commissioned until the corresponding Gen-Sets have been declared in compliance with the Directives Nr 2006/42/CE et 2004/108/CE, as well as with the other relevant Directives.

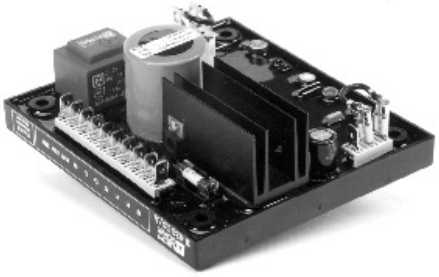
Technical Managers

P Betge – O Cadel

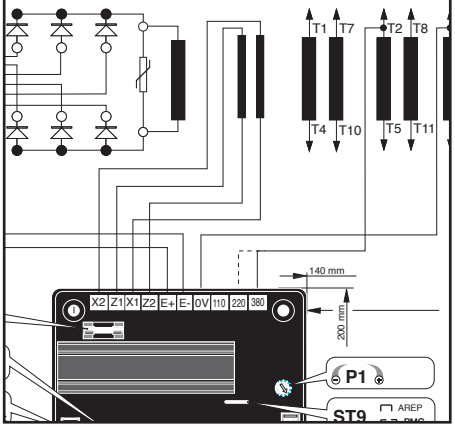
4152 en – 12.2009 / c

LEROY SOMER

3971 en - 2010.11 / f



This manual is to be given to the end user



R438

A.V.R.

Installation and maintenance

189/202

R438
A.V.R.

This manual concerns the alternator A.V.R. which you have just purchased.

We wish to draw your attention to the contents of this maintenance manual. By following certain important points during installation, use and servicing of your A.V.R., you can look forward to many years of trouble-free operation.

SAFETY MEASURES

Before using your machine for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this machine must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional infor-mation you may require.

The various operations described in this manual are accompanied by recommen-dations or symbols to alert the user to potential risks of accidents. It is vital that you understand and take notice of the following warning symbols.

This A.V.R. can be incorporated in a machine marked C.E.

WARNING

Warning symbol for an operation capable of damaging or destroying the machine or surround-ing equipment.

Warning symbol for general danger to personnel.

Warning symbol for electrical danger to personnel.

Note: LEROY-SOMER reserves the right to modify the characteristics of its products at any time in order to incorporate the latest technological developments. The information contained in this document may therefore be changed without notice.

R438
A.V.R.

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All such operations performed on the A.V.R. should be undertaken by personnel trained in the commissioning, servicing and maintenance of electrical and mechanical components.

The R438 is an IP00 product. It must be installed inside a unit so that this unit's cover can provide IP20 minimum total protection (it must only be installed on LS alternators in the appropriate location so that when viewed externally, it has a higher degree of protection than IP20).

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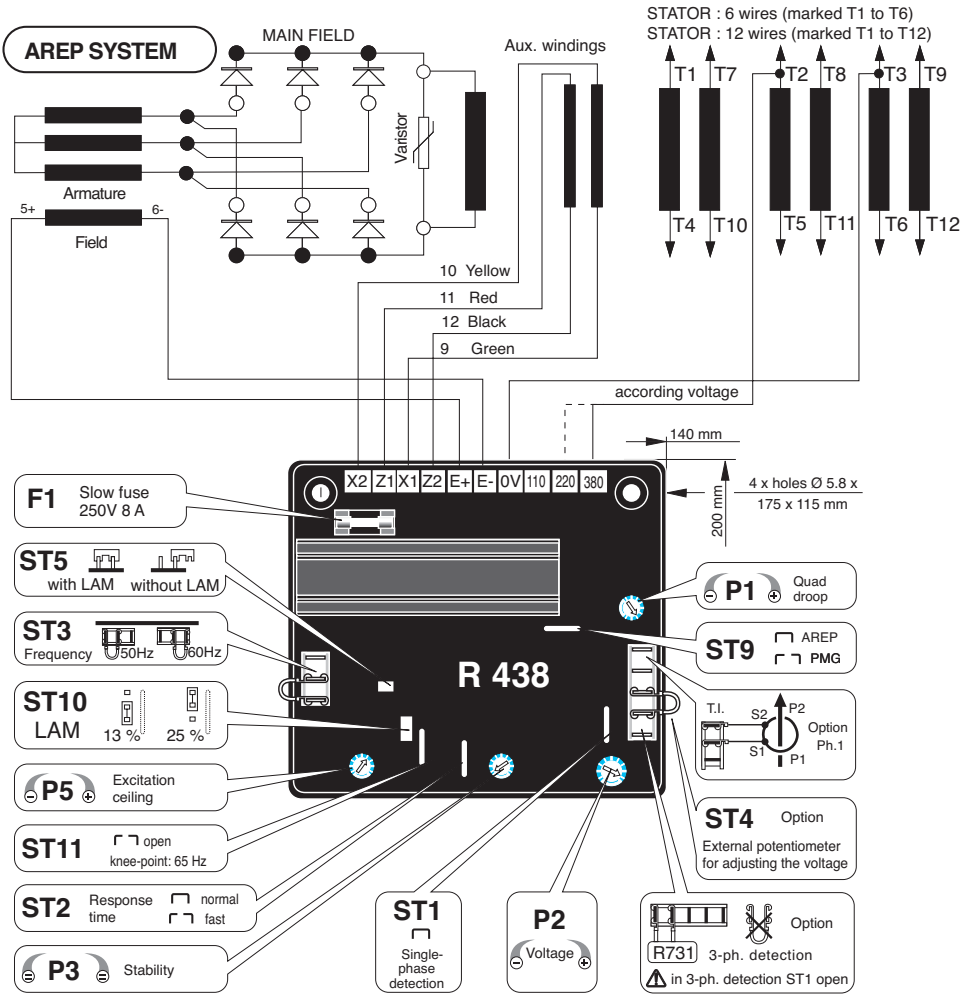
R438
A.V.R.

1 - SUPPLY

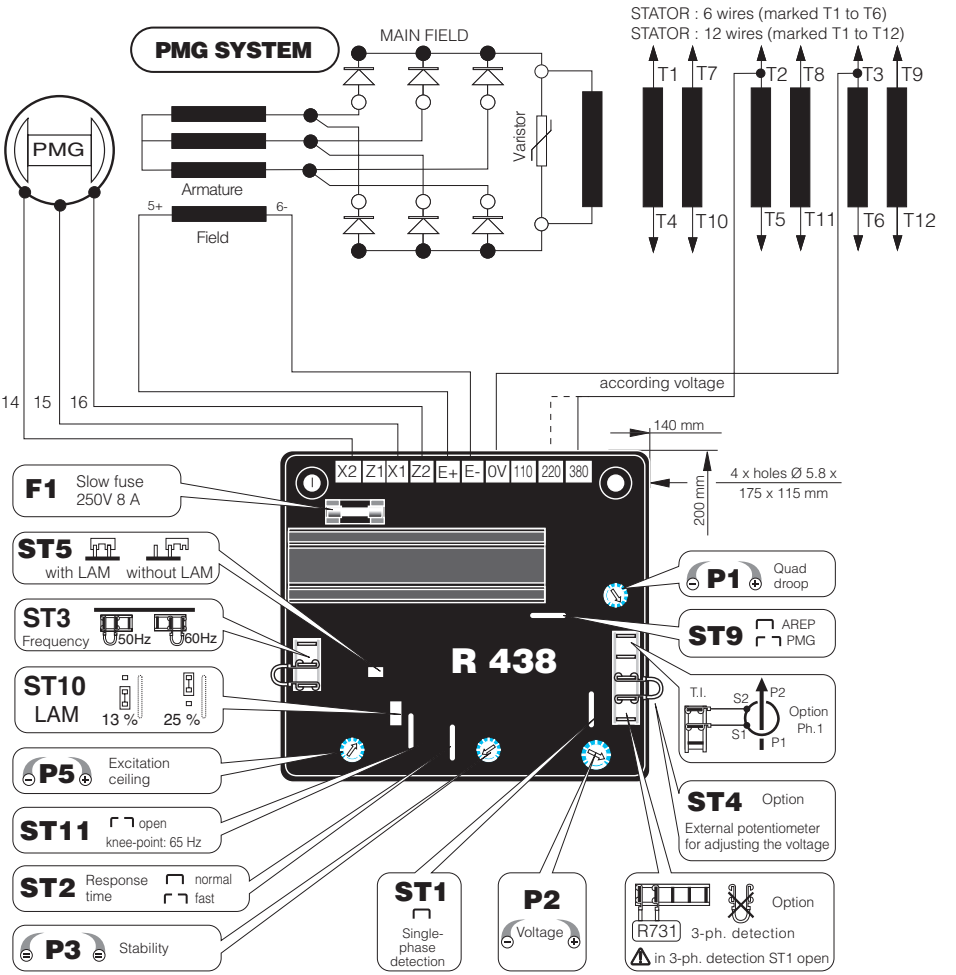
1.1 - AREP excitation system

For both AREP & PMG excitation systems, the alternator voltage regulator is the R438. With **AREP** excitation, the R438 electronic AVR is powered by two auxiliary windings which are independent of the voltage match circuit.
The first winding has a voltage in proportion to that of the alternator (characteristic Shunt), the second has a voltage in proportion to the stator current (compound characteristic: Booster effect).
The power supply voltage is rectified and filtered before being used by the AVR monitoring transistor. This principle ensures that regulation is not affected by distortions generated by the load.



1.2 - PMG excitation system

This excitation system consists of a «**PMG**» (permanent magnet generator). This is fitted at the rear of the machine and connected to the R438 AVR.
The PMG supplies the AVR with constant voltage which is independent of the main alternator winding. As a result the machine has a short-circuit current capacity and good immunity to distortions generated by the load.
The AVR monitors and corrects the alternator output voltage by adjusting the excitation current.
- 50/60 Hz selection via the **ST3** jumper.



1.3 - SHUNT or separate excitation system

A.V.R. can be operated with SHUNT supply (with a transformer / secondary 50V or a 48V battery).

2 - R438 A.V.R.

2.1 - Characteristics

- Storage : -55°C ; +85°C
- Operation : -40°C ; +70°C
- Standard power supply: AREP or PMG.
- Rated overload current: 8 A - 10 s
- Electronic protection (overload, short-circuit on opening of voltage sensing circuit): excitation overload current for 10 seconds then return to approximately 1A. The alternator must be stopped (or the power switched off) in order to reset the protection.
- Fuse : F1 on X1, X2. 8A ; slow - 250V
- Voltage sensing : 5 VA isolated via transformer ;
  - 0-110 V terminals = 95 to 140 V,
  - 0-220 V terminals = 170 to 260 V,
  - 0-380 V terminals = 340 to 520 V.
- Voltage regulation ± 1%.
- Normal or rapid response time via **ST2** jumper (see below).
- Voltage adjustment via potentiometer **P2**. other voltages via adapter transformer
- Current sensing (parallel operation): C.T. 2.5 VA cl1, secondary 1 A (optional).
- Quadrature droop adjustment via potentiometer **P1**.
- Max. excitation current adjustment via **P5** (see below).

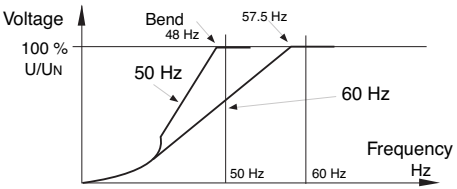
2.1.1 - Configuration jumpers function

Pot.	Delivrery config.		Position	Function
	Open	Closed		
ST1	3-ph.	Mono		Open for module installation tri detection
ST2	Fast	Normal		Response time
ST3			50 ou 60 Hz	Frequency selection
ST4	External potentio-meter	Without		Potentiometer
ST5	Without	With		LAM
ST9	Others (PMG...)	AREP		Supply
ST10			13% or 25%	LAM voltage drop amplitude
ST11	65 Hz	48 or 58 Hz		U/f function bend position

2.1.2 - Setting potentiometers function

Delivrery position	Pot.	Function
0	P1	Quadrature droop ; // operation with C.T.
400V	P2	Voltage
Centre	P3	Stability
Maxi	P5	Excitation current ceiling

2.2 - Frequency compared with voltage (without LAM)

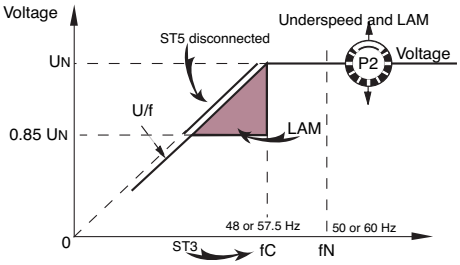


2.3 - LAM (Load Acceptance Module) characteristics

2.3.1 - Voltage drop

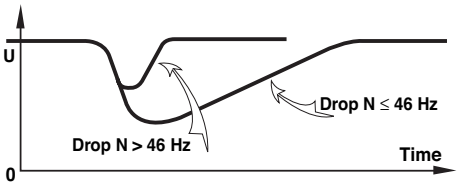
The LAM system is integrated in the R 438 AVR as standard.
Role of the «LAM» (Load Adjustment Module) :
On application of a load, the rotation speed of the generator set decreases. When it passes below the preset frequency threshold, the LAM causes the voltage to drop by approximately 13% or 25% and consequently the amount of active load applied is reduced by approximately 25% to 50%, until the speed reaches its rated value again.
Hence the LAM can be used either to reduce the speed variation (frequency) and its duration for a given applied load, or to increase the applied load possible for one speed variation (turbo-charged engine).
To avoid voltage oscillations, the trip threshold for the LAM function should be set approximately 2 Hz below the lowest frequency in steady state.

- LAM : action eliminated by cutting the ST5 jumper.



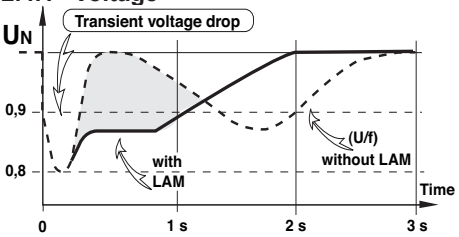
2.3.2 - Gradual voltage return function

During load impacts, the function helps the genset to return to its rated speed faster thanks to a gradual increase in voltage according to the principle:
- If the speed drops between 46 and 50 Hz, the rated voltage follows a fast gradient as it is restored.
- If the speed drops below 46 Hz, since the engine needs more help, the voltage follows a slow gradient as it returns to the reference value.

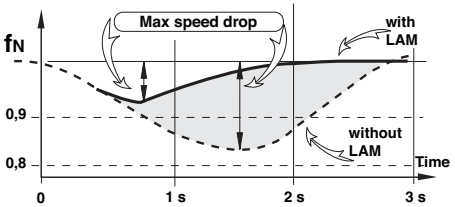


2.4 - Typical effects of the LAM with a diesel engine with or without a LAM (U/F only)

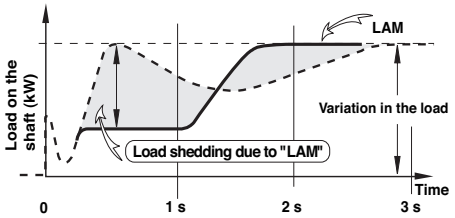
2.4.1 - Voltage



2.4.2 - Frequency



2.4.3 - Power



2.5 - R438 A.V.R. options

- **Current transformer** for parallel operation of ...../1A. 5 VA CL 1.

- **Remote voltage adjustment potentiometer**: 470 Ω, 0.5 W min: adjustment range ± 5% (range limited by internal voltage potentiometer **P2**). Remove ST4 to connect the poten-tiometer. (A 1 kΩ potentiometer can also be used to extend the adjustment range).

For wiring up the external potentiometer; the "earth" wires must be isolated as well as the potentiometer terminals (wires at the same voltage as the power).

- **R 731 external module**: sensing of 3-phase voltage 200 to 500 V, compatible with parallel operation. Disconnect ST1 to connect the module; set the voltage via the module potentiometer.

- **R 734 module**: detection of 3-phase current and voltage for parallel operation on unbalanced installations (imbalance > 15%).

- **R 726 module**: 3 functions (mounted externally).
P.F. regulation (2F) and voltage sensing circuit before paralleling (3 F).

- **Control through DC voltage** used monitoring apply to the terminals for connection of a potentiometer DC voltage :
• internal impedance 1,5 kΩ
• ± 0,5V enable a voltage setting of 10%.

3 - INSTALLATION - COMMISSIONING

3.1 - Electrical checks on the AVR

- Check that all connections have been made properly as shown in the attached wiring diagram.
- Check that the ST3 frequency selection jumper is on the correct frequency setting.
- Check whether the ST4 jumper or the remote adjustment potentiometer have been connected.
- Optional operating modes.
  • ST1 jumper : open to connect the R 731or R 734 3-phase sensing module.
  • ST2 jumper : open if rapid response time used
  • ST5 jumper : open to suppress the LAM function.

3.2 - Settings

The machine is tested and set at the factory. When first used with no load, make sure that the drive speed is correct and stable (see the nameplate). After operational testing, replace all access panels or covers.
The only possible adjustments to the machine should be made on the AVR.

3.2.1 - R438 settings (AREP or PMG system)

WARNING

Before any intervention on the A.V.R., make sure that the ST9 jumper is closed with AREP excitation and disconnected with PMG or SHUNT or separate excitation.

a) Initial potentiometer settings (see table below)
- Remote voltage adjustment potentiometer : centre (ST4 jumper removed).

Action	Factory setting	Pot.
Voltage minimum fully anti-clockwise	400V - 50 Hz (Input 0 - 380 V)	
Stability	Not set (centre position)	
Voltage quadrature droop (// operation with C.T.) - 0 quadrature loop fully anti-clockwise.	Not set (fully anti-clockwise)	
Excitation ceiling Limit of excitation and short-circuit current, minimum fully anti-clockwise.	10 A maximum	

Stability adjustments in standalone operation

b) Install a D.C. analogue voltmeter (needle dial) cal. 50V on terminals E+, E- and an A.C. voltmeter cal 300 - 500 or 1000V on the alternator output terminals.

c) Make sure that the **ST3** jumper is positioned on the desired frequency (50 or 60 Hz).

d) Voltage potentiometer **P2** at minimum, fully anti-clockwise.

e) Stability potentiometer **P3** to around 1/3 of the anti-clockwise limit.

f) Start the engine and set its speed to a frequency of 48 Hz for 50 Hz, or 58 for 60 Hz.

g) Set the output voltage to the desired value using **P2**.
- Rated voltage UN for solo operation (eg. 400 V)
- Or UN + 2 to 4% for parallel operation with C.T. (eg. 410 V)
If the voltage oscillates, use P3 to make adjustments (try both directions) observing the voltage between E+ and E- (approx. 10V D.C.).

The best response times are obtained at the limit of the instability. If no stable position can be obtained, try disconnecting or replacing the ST2 jumper (normal/fast).

h) Check LAM operation : **ST5** closed.

i) Vary the frequency (speed) around 48 or 58 Hz according to the operating frequency, and check the change in voltage from that observed previously (~ 15%).

j) Readjust the speed of the unit to its rated no-load value.
Adjustments in parallel operation

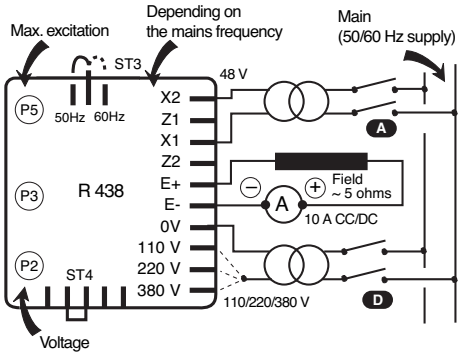
Before any intervention on the alternator, make sure that the speed droop is identical for all engines.

k) Preset for parallel operation (with C.T. connected to S1, S2)
- Potentiometer P1 (quadrature droop) in centre position.
Apply the rated load (cos φ = 0.8 inductive). The voltage should drop by 2 to 3%. If it increases, check that V and W and also S1 and S2 have not been reversed.

l) The no-load voltages should be identical for all the alternators intended to run in parallel.
- Couple the machines in parallel.
- By adjusting the **speed**, try to obtain **0 KW** power exchange.
- By altering the voltage setting P2 on one of the machines, try to cancel (or minimise) **the current** circulating between the machines.
- From now on, do not touch the voltage settings.

m) Apply the available load (the setting is only correct if a **reactive** load is available)
- By altering the **speed**, match the **kW** (or divide the rated power of the units proportionally)
- By altering the quadrature droop potentiometer **P1**, match or divide the **currents**.

3.2.2 - Max. excitation setting (excitation ceiling)



Static adjustment of the current limit, potentiometer P5 (factory setting: 7.5 A, fuse rating: 8 A - 10 seconds).

The maximum factory setting corresponds to that of the excitation current required to obtain a 3-phase short-circuit current of approximately 3 IN at 50 Hz for industrial power, unless otherwise specified(*).

A static method can be used to reduce this value or adapt the Isc to the actual operating power (derated machine), which is safer for the alternator and the installation. Disconnect power supply wires X1,X2 and Z1,Z2 and the voltage reference (0-110V-220V-380V) on the alternator.

Connect the mains power supply using a transformer (200-240V) as indicated (X1,X2 : 48V). Install a 10A D.C. ammeter in series with the exciter field. Turn P5 fully anti-clockwise and activate the power supply. If there is no output current from the AVR, turn potentiometer P2 (voltage) clockwise until the ammeter indicates a stable current. Switch the power supply off, then on again, turn P5 clockwise until the required max. current is obtained (no more than 8 A).

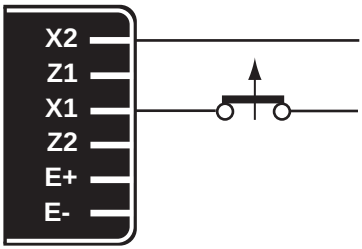
Checking the internal protection :
Open switch (D) : the excitation current should increase to its preset ceiling, remain at that level for ≥ 10 seconds and then drop to < 1A.
To reset, switch off the power supply by opening switch (A).
Note: After setting the excitation ceiling as described, adjust the voltage again (see section 2.1.1)
(*) In some countries it is a legal requirement to have a short-circuit current of 3 I_N, so as to offer selective protection.

3.2.3 - Special type of use

WARNING

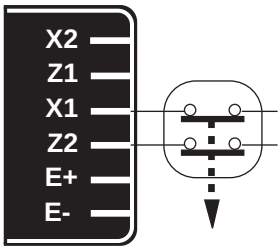
Excitation circuit E+, E- must not be left open when the machine is running : AVR damage will occur.

3.2.3.1 - R438 field weakening (SHUNT)



The exciter is switched off by disconnecting the AVR power supply (1 wire - X1 or X2).
Contact rating 16 A - 250V A.C.

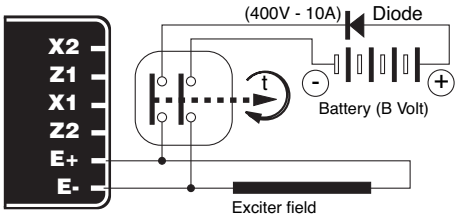
3.2.3.2 - R438 field weakening (AREP/ PMG)

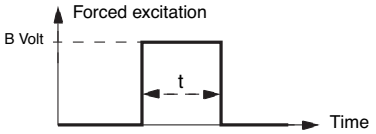


The exciter is switched off by disconnecting the AVR power supply (1 wire on each auxiliary winding) - contact rating 16 A - 250V A.C.
Connection is identical for resetting the AVR internal protection.

In case of using the de-excitation, provide a forced excitation.

3.2.3.3 - R438 field forcing





Applications	B volts	Time t
Guaranteed voltage build-up	12 (1A)	1 - 2 s
Parallel operation, de-energized	12 (1A)	1 - 2 s
Parallel operation, at standstill	12 (1A)	5 - 10 s
Frequency starting	12 (1A)	5 - 10 s
Sustained voltage on overload	12 (1A)	5 - 10 s

3.3 - Electrical faults

Fault	Action	Effect	Check/Cause
No voltage at no load on start-up	Connect a new battery of 4 to 12 volts to terminals E- and E+, respecting the polarity, for 2 to 3 seconds	The alternator builds up and its voltage is still correct when the battery is removed.	- Lack of residual magnetism
		The alternator builds up but its voltage does not reach the rated value when the battery is removed.	- Check the connection of the voltage reference to the AVR - Faulty diodes - Armature short-circuit
		The alternator builds up but its voltage disappears when the battery is removed	- Faulty AVR - Field windings disconnected - Main field winding open circuit - check the resistance
Voltage too low	Check the drive speed	Correct speed	Check the AVR connections (AVR may be faulty) - Field windings short-circuited - Rotating diodes burnt out - Main field winding short-circuited - Check the resistance
		Speed too low	Increase the drive speed (Do not touch the AVR voltage pot. (P2) before running at the correct speed.)
Voltage too high	Adjust AVR voltage potentiometer	Adjustment ineffective	Faulty AVR
Voltage oscillations	Adjust AVR stability potentiometer	If no effect : try normal / fast recovery modes (ST2)	- Check the speed : possibility of cyclic irregularity - Loose connections - Faulty AVR - Speed too low when on load (or U/F bend set too high)
Voltage correct at no load and too low when on load (*)	Run at no load and check the voltage between E+ and E- on the AVR	Voltage between E+ and E- SHUNT < 20 V AREP / PMG < 10V	- Check the speed (or U/F bend set too high)
		Voltage between E+ and E- SHUNT > 30V AREP / PMG > 15V	- Faulty rotating diodes - Short-circuit in the main field. Check the resistance - Faulty exciter armature.
(*) Caution : For single-phase operation, check that the sensing wires coming from the AVR are correctly connected to the operating terminals			
Voltage disappears during operation (**)	Check the AVR, the surge suppressor, the rotating diodes, and replace any defective components	The voltage does not return to the rated value.	- Exciter winding open circuit - Faulty exciter armature - Faulty AVR - Main field open circuit or short-circuited
(**) Caution : Internal protection may be activated (overload, open circuit, short-circuit)			

Warning : after operational testing, replace all access panels or covers.

4 - SPARE PARTS

4.1 - Designation

Description	Type	Code
A.V.R.	R 438	AEM 110 RE 017

4.2 - Technical support service

Our technical support service will be happy to provide any information you require.

When ordering spare parts, you should indicate the complete machine type, its serial number and the information indicated on the nameplate.

Part numbers should be identified from the exploded views and their description in the parts list.

Our extensive network of «service stations» can dispatch the necessary parts without delay.
To ensure correct operation and the safety of our machines, we recommend the use of original manufacture spare parts.
In the event of failure to comply with this advice, the manufacturer cannot be held responsible for any damage.

R438

NOTES